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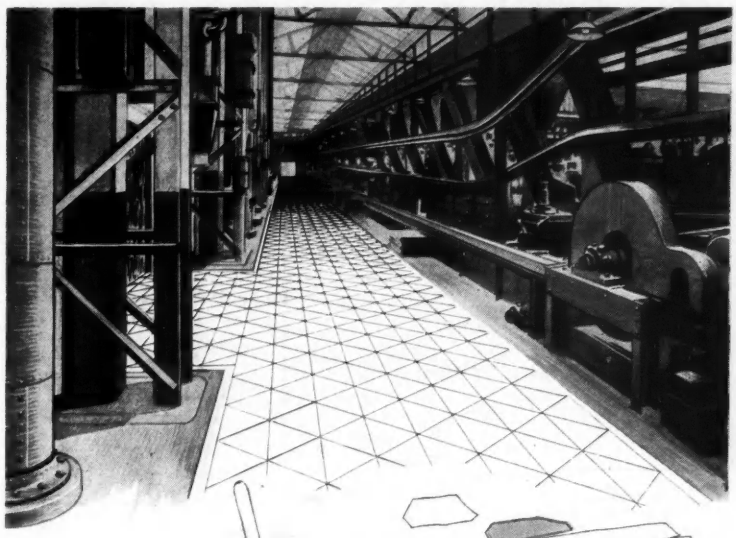

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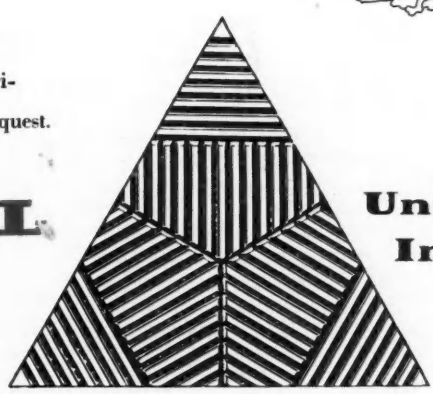

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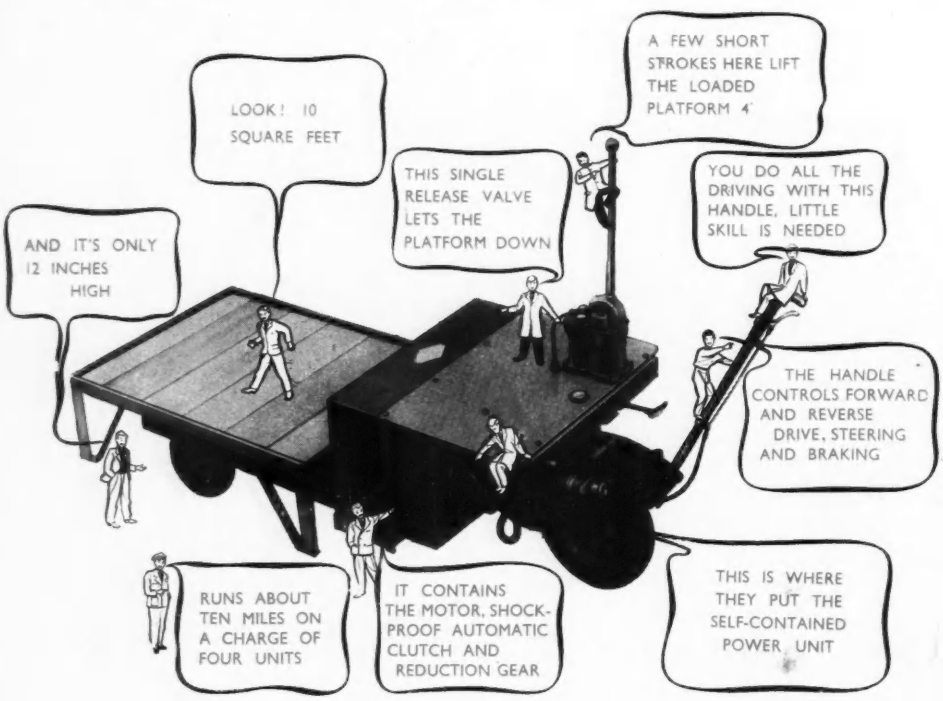
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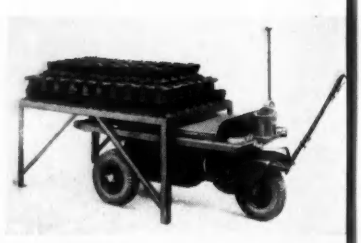

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THE ENGINEER

MARCH 18, 1955

Science Teachers and Industry

THE Federation of British Industries has addressed a letter to the 7000 firms and 300 trade associations which comprise its membership on the shortage of science teachers in schools. Some weeks ago, the Minister of Education asked the Burnham Committee to consider the question of salaries of teachers in relation to advanced work in schools. Last week, the Minister stated in Parliament that the Government had decided to accept the Burnham Committee's proposals. He said that the proposed increases in pay would greatly improve the career prospects of science teachers, and added that the Government was reviewing the whole question of scientists in the public service, so as to ensure that the best and most economical use was made of them in the national interest. In the letter which it has circulated, the F.B.I. says that, in the course of its discussions with the Government, the suggestion was made that "a hopeless situation would arise if the increased remuneration for teachers was countered by the corresponding raising of salary levels by industry," and the Government expressed the hope that industry would not allow such a position to arise. Forbearance on the part of industry, the F.B.I. says, may perhaps be a little easier to exercise if firms will review the use they make of scientific staff. In some kinds of work, for example, it may be possible to employ technicians instead of science graduates, while in certain instances, the letter suggests that arts graduates may prove just as suitable as scientists or engineers, so that in one way or another scientific staffs may be reserved for the really essential work for which they are best fitted. It is also suggested that some relief may be afforded by retaining scientific staff beyond the normal retiring age. Since the announcement by the Minister of Education and the publication of the F.B.I. suggestion, some comment on the matter has been made by the Institution of Professional Civil Servants. The Institution asserts that the appeal to industry not to raise pay for scientists in relation to the Government's increases to teachers "is illustrative of the general failure of the Government to cope with the serious shortage of scientific manpower."

Institute of Marine Engineers' Annual Dinner

ON Friday, March 11th, the fifty-second annual dinner of the Institute of Marine Engineers was held at Grosvenor House, Park Lane, London, and was attended by about 1200 members and their guests, with Mr. H. A. J. Silley, the president, in the chair. The first toast was "The Right Honourable the Lord Mayor of the City of London and the Sheriffs" and was proposed by the president, who discussed the various duties and responsibilities of the Lord Mayor and suggested that traffic congestion in streets pointed to the river being the best place for the annual procession. In his reply, the Lord Mayor commented that the Institute of Marine Engineers was the only technical society in the City of London and went on to trace the growth of our maritime tradition from the times of the Norsemen to the present day, when the future of the country continued to depend upon sea power. His Excellency The Marquis du Parc-Locmaria, the Belgian Ambassador, proposed "The Royal and Merchant Navies of the British Commonwealth" and after mentioning the war service of the Belgian merchant marine with the British Merchant Navy, went on to praise the Royal Navy, upon which the present-day Belgian Navy was founded and in which it had its roots. In his reply, Mr. A. I. Anderson, the president of the Chamber of Shipping, made reference to the growing competition of air power but emphasised that without ships the country would starve and that aircraft would be grounded. He briefly reviewed the evolution from sail to steam and noted that ship development, operation and economics, called more and more upon the services of the engineer. Although British ships, he said, had always been in the van of progress, there was no divine providence to guarantee that the Merchant Navy would remain there. Tradition, continued Mr. Anderson, was not enough to meet the fierce competition of to-day, so that it was necessary to produce new ships which would be another landmark in our island story. The Lord Advocate, The Right Honourable W. R. Milligan, Q.C., proposed the toast of "The Institute of Marine Engineers," and the president, in the course of his reply, called attention to the flourishing condition of The Institute, which now had more than 8500 members. He stated that the memorial building, the scheme for which was begun ten years ago, was expected to be ready for occupation within three years.

Bronze and Brass Founding

THE British Productivity Council has published a review of productivity in the bronze and brass founding industry of this country. It recalls that in 1950 a team representing all sections of the brass foundry industry visited the U.S.A. and says that, since then, the industry has made great strides from a technological point of view. The adoption of shell moulding, aluminium alloy match-plates and the flexible and reinforced abrasive wheel are some of the developments which are specially mentioned. But, the review says, the industry suffers to some extent from the lack of large capital resources, the effect of which has been to impose a handicap on developments by certain individual firms. This position, the review suggests, could be improved by closer co-operative action, and it is urged that there should be a greater measure of support for the trade and research associations concerned with the industry. Many bronze and brass foundries, according to the British Productivity Council, have not only ignored technological advances, but have also failed so far to adopt such desirable techniques as job simplification, mechanical handling, an adequate costing system, or work study. The review goes on to urge the desirability of making foundries less unsightly than some of them are at present and of ensuring that the prospects offered by the bronze and brass founding industry become better-known among school leavers. An appendix to the review contains a series of case histories of both jobbing and specialist foundries of all sizes in various parts of the country. From these histories, it is apparent that the steps taken to increase efficiency vary considerably; some firms attribute their advance to the adoption of new technical processes, some to new layouts and some to increased mechanisation, while others acknowledge the usefulness of incentive and work study schemes.

Improved Traffic Controls at the Monument

A SYSTEM of vehicle-actuated automatic traffic signals was inaugurated on Tuesday at the Monument junction north of London Bridge by the Lord Mayor of London, Sir Seymour Howard. It is similar to one which has been operating successfully at the Bank since 1947, and extensive tests were undertaken, prior to the change-over, by City Police and Ministry of Transport officials in order to determine the advantages to be gained. At a census taken in the summer of 1952, it was found that nearly 28,000 vehicles passed through the junction in the twelve hours between 8 a.m. to 8 p.m., of which 16,000 passed on the route London Bridge–Gracechurch Street. For manual control, at least six police constables and one sergeant were required. During the trials, the constables directed the traffic according to hand signals given from a central control point on a prearranged plan. It was found that peak morning traffic could readily be handled in this manner, a full cycle taking between eighty-five and ninety seconds. At a reception given after the inauguration by the manufacturers of the equipment, the Automatic Telephone and Electric Company, Ltd., the Lord Mayor stressed the importance of the new scheme which, he said, should greatly ease traffic problems at one of the busiest sections in the City.

D.S.I.R. Report for 1953–54

THE annual report of the Department of Scientific and Industrial Research for 1953-54 has been published this week. It refers to the acute shortage of staff in a number of the principal laboratories, and mentions the maintenance allowance to post-graduate students in industry. The allocation of further funds and staff to the Building Research Station is discussed at some length in the report. It is noted that although there is justification for extending research on building it is recommended that any further substantial expenditure should be paid for by sources external to the Department. It is maintained that the building industry does not contribute enough to research. The Board of the Fuel Research Station, the report continues, is acutely conscious of a staff shortage and the present inadequate premises, and emphasises that the station must maintain its position as a national centre for fuel research. Investigations there on atmospheric pollution and domestic heating are being accelerated. During 1953–54 the Advisory Council recommended new terms of grant to ten research associations. The overall effect was to increase slightly the maximum amount of Government support which they can receive, but to require them to raise substantially more industrial income to qualify for it. In addition, initial grants were recommended to two associations new to the Government scheme—the British Steel Castings Research Association and the Chalk, Lime and Allied Industries Research Association.

Liverpool Steam Ship Owners' Association Annual Report

THIS week the annual meeting of the Liverpool Steam Ship Owners' Association was held and the report for 1954 presented. The report notes that satisfactory progress has been made and that there has been an improvement in overseas trade, but it states that exports must continue to increase in order to maintain our credit balance. Although higher freight rates obtained during the year and there was a higher percentage of cargo space employed, the question of meeting the cost of tonnage replacement under conditions of high building cost and high taxation remains a problem. This problem, the report states, is particularly difficult of solution with regard to ships built before 1939 which will cost up to four times the original price to replace. Compensation for war losses, the report recalls, was insufficient so that money for normal replacement was largely absorbed to supplement the war loss compensation. The position, the report states, was aggravated by heavy taxation, which restricted the building of new tonnage, and the depreciation allowance which bore no relation to the greatly inflated post-war costs. The investment allowance, although inadequate, did recognise the problem, but, the report comments, more relief of taxation is required if British shipping is to continue its contribution to the country's prosperity, a contribution which totalled £221 million in 1952, and was no doubt more in the succeeding years. This question of maintaining the strength of our merchant fleet is an internal matter, but, the report continues, a greater danger to the survival of our fleet is the spread of flag discrimination. This practice, supported by Governments in an effort to create national mercantile fleets, restricts normal trading and the report draws attention to its effect on international trade and world economy.

Plastic Strain and Stress Relations at High Temperatures

By A. E. JOHNSON, D.Sc., M.Sc.Tech., M.I.Mech.E., N. E. FROST, B.Sc., A.M.I.Mech.E., and J. HENDERSON, B.Sc.*

No. I

The work described in this article is a further portion of a general research into the short-time combined stress properties of metallic alloys. It comprises tests made to determine the plastic-strain-stress relations for a 0·17 per cent C steel at 350 deg. and 450 deg. Cent., and an RR59 aluminium alloy at 20 deg., 150 deg. and 200 deg. Cent., under both simple and general complex stress loading conditions. A previous paper (Ref. [1]) dealt with the plastic-strain-stress relations for a magnesium alloy at 20 deg., 50 deg., 100 deg., and 150 deg. Cent. As in the case of the magnesium alloy the intent of the authors has been to explore such a range of plastic strain (1 to 2 per cent maximum) as may reasonably be expected to occur at the commencement of a normal creep test; in this sense the short time investigation is supplementary to a combined stress creep programme. Only a selection of diagrams of results is reproduced. The full set can be examined by application to the authors.

THE tests outlined in the paper on magnesium alloy were confined to simple tension, simple torsion, and simple loading combined stress tests in which the ratio of applied tension to torsion stress remains constant throughout the test. The need for general loading tests, i.e. tests in which the ratio of applied tension to torsion stress is varied throughout the test, was, however, recognised at the time in view of the considerable number of practical applications in which such circumstances may arise. It was, however, impossible in these tests to satisfy this need, since the most practical way of carrying out such tests is by fixing a static tension or torsion load of appreciable magnitude and gradually increasing the torsion or tension element of the load, and unfortunately in the case of the magnesium alloy pronounced creep occurred under such static loads which made the subsequent interpretation of results rather conjectural. However, in the present tests, no such difficulty arose, and consequently it has been possible to carry out tension, torsion, simple loading, and general loading tests at all temperatures.

It is worth while recording here that in the case of the magnesium alloy up to 100 deg. Cent. the material remained essentially isotropic, and the plastic strain stress relations were well represented by a simple St. Venant Mise relation of the general type :

$$\varepsilon_1 = A[\Sigma(\sigma_1-\sigma_2)^2]^n[(\sigma_1-\sigma_2)-(\sigma_2-\sigma_3)], \text{ \&c.}$$

At 150 deg. Cent., however, anisotropy occurred and the relations, although based upon the general St. Venant Mise relation, were modified in virtue of the anisotropy.

Particulars of the Materials Used

0·17 *Per Cent C Steel.*—This material was originally supplied as two blocks of semi-circular section, 18in in diameter and 18½in long, trepanned from an ingot of acid open-hearth steel. The material, as indicated by sulphur prints, macro etches, and chemical analyses, was satisfactorily uniform, and after heat-treatment at 950 deg. Cent. for three hours, followed by air cooling, and a final stress relieving treatment at 575 deg. Cent. for three hours, with furnace cooling, exhibited well-refined grain size, this latter being small in comparison with the wall thickness of the tubular specimens used in the tests.

RR59 Aluminium Alloy.—This material, Hiduminium RR59 alloy, was supplied in the form of a continuous cast billet, 12in diameter and 18in long. Microscopic examination of the material indicated a satisfactorily small grain size after heat-treatment at 525 deg.±5 deg. Cent. for eight hours, and quenching in boiling water followed by twenty-four hours at room temperature, and heating at 250 deg. Cent. ±3 per cent for sixteen hours with air cooling.

Both materials showed satisfactory isotropy at low and moderate stresses in combined stress creep tests at the elevated temperatures concerned in the current investigation, and this was regarded as a satisfactory criterion of their behaviour under conditions of plastic strain. The grain size in the case of both materials corresponded to five or six grains to the wall thickness, which proportion the creep research had indicated ensured homogeneous behaviour of a specimen. The specimens used were of the same design as those used in complex stress creep research, and the tests on magnesium alloy, being thin-walled (0·02in or 0·03in) tubular specimens of 2in gauge length. All specimens were machined longitudinally from the block or casting.

Outline of Experimental Work

The programme on the 0·17 per cent C steel entailed tests at 350 deg. and 450 deg. Cent. At each temperature pure tension and pure torsion tests were made. Additionally three simple loading tests in the region of values of $t/s=\frac{1}{3}$, 1 and 3 were made (the precise values of t/s are given in the tables). The t/s values of these simple loading tests correspond roughly to those made upon magnesium alloy, and were deliberately made so, to provide a link with the magnesium tests, and those on the RR59 aluminium alloy mentioned overleaf.

At each temperature two general loading tests were made—a static tension, varying torsion test, in which an initial tension load was applied and then a succession of torsion increments, and a static torsion varying tension test, in which an initial torsion load was applied followed by increments of tension. The range of t/s values covered by these tests was between 7 or 6 and 0·6. The tests constituted a progressive rotation of the principal axes of stress in one sense or the other, according as to which stress element constituted the static stress. The rate of loading in all tests was made such that the rate of increase of octahedral stress was constant in all tests. This was certainly an arbitrary arrangement, but one not likely to be very wide of the mark on general grounds. As previously indicated, the limit of plastic strain was 1 to 2 per cent.

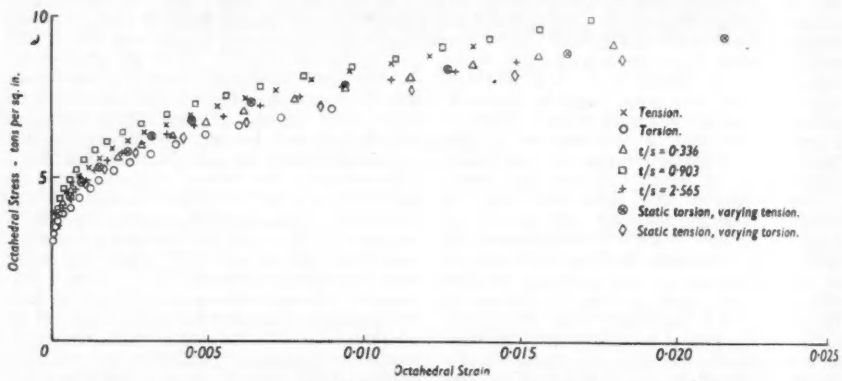


Fig. 1—General and simple loading, complex stress/plastic strain relations for 0·17 deg. Cent. steel at 350 deg. Cent.

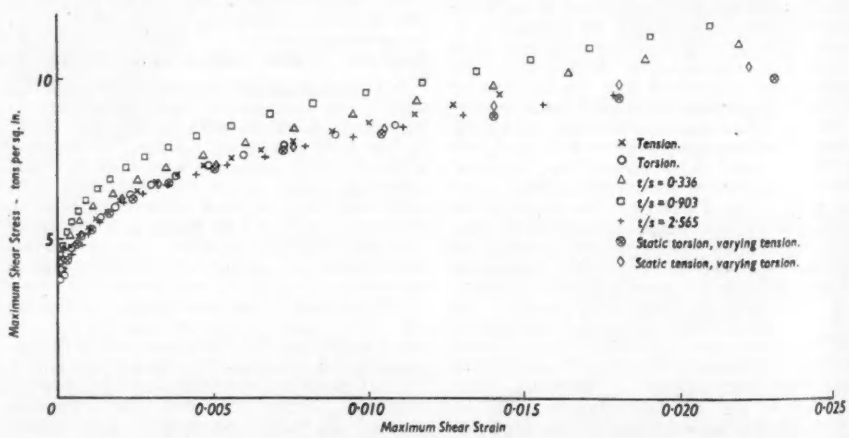


Fig. 2—General and simple loading, complex stress/plastic strain relations for 0·17 deg. Cent. steel at 450 deg. Cent.

* Mechanical Engineering Research Laboratory, Mechanics and Materials Division, East Kilbride.

In the case of the RR59 alloy the programme entailed tests at 20 deg., 150 deg. and 200 deg. Cent. at rates of loading, and to limits of plastic strain fixed as in the tests on 0·17 per cent C steel tests, and as in those tests comprised pure tension, pure torsion, simple loading tests of stress ratio $t/s=\frac{1}{3}$, 1 and 3, and two general loading† tests of the same variety as those mentioned above in reference to the C steel.

Results of Experimental Work

In Figs. 17 to 23 the values of the axial (ε_a) and shear (ε_c) strain for a number of tests will be given. In Table I details of the

Table I—*Mean Values of Characteristic Functions n_1 and A_1 for 0·17 Per Cent C Steel at 350 deg. and 450 deg. Cent., and for RR59 Alloy at 20 deg., 150 deg. and 200 deg. Cent.*

Material	Temperature	Mean value of n_1	Mean value of A_1
0·17 per cent C steel	350	2·0	$5·1\times10^{-10}$
	450	2·2	$3·5\times10^{-10}$
RR59 aluminium alloy	20	3·2	$6·5\times10^{-10}$
	150	4·5	$3·8\times10^{-10}$
	200	5·0	2×10^{-10}

anisotropy coefficients, and the characteristic constants of n_1 and A_1, for the materials are given; Figs. 24 and 25 will give details of anisotropy constants. In Figs. 1–4 the experimentally derived values of the octahedral plastic strains and the maximum shear plastic strains are plotted against the corresponding octahedral stress, or maximum shear stress for each material, and one temperature in each case, while in Figs 5–9 plots are shown of log octahedral plastic strain against log octahedral stress, at all temperatures for the two materials.

The Figs. 10–16 will display the relation of the ratio $\varepsilon_a/\varepsilon_c$ to t/s at all temperatures for the two materials, where ε_a and ε_c are respectively axial and shear strains, and t and s axial and shear stresses. Tables II to VI give the values of ratios of principal strains $\varepsilon_2/\varepsilon_1$ and $\varepsilon_3/\varepsilon_1$ for all tests.

Discussion of the Results of Experimental Work: The Criterion of Limit of Elasticity

In the previous work on magnesium alloy no clearly defined elastic limits were exhibited, and accordingly it was impossible to make any conjecture as to the criterion of the limit of elasticity. In the present tests, however, both materials at all temperatures showed a quite well-defined departure from the elastic line, and it was accordingly possible to estimate the maximum shear stress, the octahedral stress (representing the criterion of shear strain energy), and the maximum principal stress values, with satisfactory accuracy for all tests, both simple and general loading.

For the 0·17 per cent C steel at 350 deg. and 450 deg. Cent. it was obvious that the criterion was not the maximum principal stress. It appeared, however, that octahedral stress and maximum shear stress were almost equally suitable with the preference just lying with the former. For the RR59 alloy the same remarks applied in reference to the maximum principal stress, and at 20 deg. Cent. maximum shear stress appeared a little more suitable than octahedral stress; at 150 deg. Cent. they appeared equally suitable, while at 200 deg. Cent. the octahedral stress appeared preferable. Apparently, therefore, for these materials and temperatures there is little to choose between octahedral

† With the exception of 200 deg. Cent. on RR59 alloy. Here insufficient specimens were available to complete the general loading tests.

Table II—*Complex Stress/Plastic Strain Relations for 0·17 Per Cent C Steel at 350 deg. Cent. Values of Ratios of $\varepsilon_2/\varepsilon_1$ and $\varepsilon_3/\varepsilon_1$ of Principal Strains*

Simple loading test, $t/s=2·57$		Simple loading test, $t/s=0·90$		Simple loading test, $t/s=0·335$		General loading test, static torsion 2·70 tons per square inch, varying tension		General loading test static tension 6·29 tons per square inch, varying torsion	
Tensile stress, tons per square inch	$\varepsilon_2/\varepsilon_1$	Tensile stress, tons per square inch	$\varepsilon_2/\varepsilon_1$	Tensile stress, tons per square inch	$\varepsilon_2/\varepsilon_1$	Tensile stress, tons per square inch	$\varepsilon_2/\varepsilon_1$	Torsion stress, tons per square inch	$\varepsilon_2/\varepsilon_1$
6·20	−0·42	3·71	−1·12	1·43	−0·66	5·71	−2·13	2·02	+0·62
7·20	−0·80	4·29	−1·22	1·71	−0·95	6·86	−1·48	2·70	−1·12
8·20	−0·94	4·86	−1·20	2·00	−0·97	8·00	−1·94	3·37	−1·24
9·20	−0·97	5·43	−1·16	2·29	−1·01	9·14	−1·95	4·04	−1·21
10·20	−0·96	6·00	−1·09	2·57	−1·00	10·29	−1·91	4·72	−1·12
11·20	−0·91	6·57	−1·04	2·86	−1·01	11·43	−1·83	5·39	−1·05
12·20	−0·83	7·14	−1·05	3·14	−1·02	12·57	−1·67	6·07	−1·04
13·20	−0·79	7·71	−1·03	3·43	−1·01	13·71	−1·54	6·74	−1·04
14·20	−0·81	8·29	−1·04	3·71	−1·02	14·86	−1·57	7·41	−1·00
15·20	−0·83	8·86	−1·01	—	—	16·00	−1·66	8·09	−0·95
—	—	—	—	—	—	17·14	−1·68	8·76	−0·97
—	—	—	—	—	—	18·29	−1·77	9·44	−0·96
—	—	—	—	—	—	19·43	−1·90	10·11	−0·95

In all cases $\varepsilon_3/\varepsilon_1=-(1+\varepsilon_2/\varepsilon_1)$ and for pure torsion in all cases $\varepsilon_2/\varepsilon_1=-1$ and $\varepsilon_3/\varepsilon_1=0$.

Table III—*Complex Stress/Plastic Strain Relations for 0·17 Per Cent C Steel at 450 deg. Cent. Values of Ratios $\varepsilon_2/\varepsilon_1$ and $\varepsilon_3/\varepsilon_1$ of Principal Strains*

Simple loading test, $t/s=2·67$		Simple loading test, $t/s=0·34$		Simple loading test, $t/s=0·82$		General loading test, static torsion 2·36 tons per square inch, varying tension		General loading test, static tension 4·57 tons per square inch, varying torsion	
Tensile stress, tons per square inch	$\varepsilon_2/\varepsilon_1$	Tensile stress, tons per square inch	$\varepsilon_2/\varepsilon_1$	Tensile stress, tons per square inch	$\varepsilon_2/\varepsilon_1$	Tensile stress, tons per square inch	$\varepsilon_2/\varepsilon_1$	Torsion stress, tons per square inch	$\varepsilon_2/\varepsilon_1$
5·50	−1·68	1·21	−0·082	2·86	−0·31	5·43	−0·86	2·53	−2·33
6·50	−0·66	1·50	−0·94	3·43	−0·54	6·57	−0·50	3·20	−1·14
7·50	−0·70	1·79	−0·87	4·00	−0·91	7·71	−0·50	3·88	−0·95
8·50	−0·68	2·07	−0·90	4·57	−0·74	8·86	−0·63	4·55	−0·97
9·50	−0·71	2·36	−0·91	5·14	−0·87	10·00	−0·87	5·22	−0·95
10·50	−0·74	2·64	−0·90	5·71	−0·76	11·14	−1·04	5·90	−0·93
11·50	−0·72	2·93	−0·87	6·29	−0·78	12·29	−1·23	7·25	−0·93
12·50	−0·72	3·21	−0·88	6·86	−0·72	13·43	−1·30	8·59	−0·91
—	—	—	—	7·43	−0·76	—	—	—	—
13·50	−0·75	—	—	8·00	−0·77	14·57	−1·07	—	—
—	—	—	—	8·57	−0·74	—	—	—	—

In all cases $\varepsilon_3/\varepsilon_1=-(1+\varepsilon_2/\varepsilon_1)$, and for pure torsion in all cases $\varepsilon_2/\varepsilon_1=-1$ $\varepsilon_3/\varepsilon_1=0$.

Table IV—*Complex Stress/Plastic Strain Relations for RR59 Aluminium Alloy at 20 deg. Cent. Values of Ratios $\varepsilon_2/\varepsilon_1$ and $\varepsilon_3/\varepsilon_1$ of Principal Strains*

Simple loading test, $t/s=3·1$		Simple loading test, $t/s=1·2$		Simple loading test, $t/s=0·33$		General loading test, static tension stress 7·14 tons per square inch		General loading test, static torsion stress 3·71 tons per square inch	
Tensile stress, tons per square inch	Value $\varepsilon_2/\varepsilon_1$	Tensile stress, tons per square inch	Value $\varepsilon_2/\varepsilon_1$	Tensile stress, tons per square inch	Value $\varepsilon_2/\varepsilon_1$	Shear stress, tons per square inch	Value $\varepsilon_2/\varepsilon_1$	Tensile stress, tons per square inch	Value $\varepsilon_2/\varepsilon_1$
7·15	−1·38	5·01	−1·74	2·14	−0·96	2·9	−0·96	4·22	−0·59
7·87	−2·01	5·72	−1·96	2·33	−0·85	3·57	−2·5	5·64	−0·25
8·60	−1·37	6·45	−2·07	2·50	−0·97	4·25	−2·03	7·07	−0·77
9·31	−0·67	7·15	−1·66	2·68	−0·97	4·92	−1·52	8·50	−1·17
10·01	−0·67	7·87	−1·51	2·82	−0·97	5·6	−1·21	9·93	−1·39
10·73	−0·87	8·60	−1·39	3·04	−0·94	6·27	−1·14	11·36	−1·52
11·45	−0·65	9·31	−1·48	3·22	−0·96	6·94	−1·11	12·79	−1·47
12·18	−0·67	9·67	−1·58	3·40	−0·92	7·62	−1·02	14·22	−1·62
12·89	−0·68	—	—	—	—	8·29	−0·99	14·93	−1·80
13·60	−0·69	—	—	—	—	8·63	−0·96	—	—
13·97	−0·51	—	—	—	—	—	—	—	—

In all cases $\varepsilon_3/\varepsilon_1=-(1+\varepsilon_2/\varepsilon_1)$, and for pure torsion in all cases $\varepsilon_2/\varepsilon_1=-1$, and $\varepsilon_3/\varepsilon_1=0$.

Table V—*Complex Stress/Plastic Strain Relations for RR59 Aluminium Alloy at 150 deg. Cent. Values of Ratios $\varepsilon_2/\varepsilon_1$ and $\varepsilon_3/\varepsilon_1$ of Principal Strains*

Simple loading test, $t/s=3·8$		Simple loading test, $t/s=1·25$		Simple loading test, $t/s=0·41$		General loading test, static torsion stress 3 tons per square inch		General loading test, static tension stress 4·5 tons per square inch	
Tensile stress, tons per square inch	Value $\varepsilon_2/\varepsilon_1$	Tensile stress, tons per square inch	Value $\varepsilon_2/\varepsilon_1$	Tensile stress, tons per square inch	Value $\varepsilon_2/\varepsilon_1$	Tensile stress, tons per square inch	Value $\varepsilon_2/\varepsilon_1$	Shear stress, tons per square inch	Value $\varepsilon_2/\varepsilon_1$
6·80	−0·84	5·01	−1·61	2·06	−0·71	6·45	−0·44	4·05	−2·70
7·50	−0·80	5·37	−1·04	2·24	−0·82	7·15	−0·51	4·72	−1·34
8·23	−0·76	5·73	−1·20	2·42	−1·02	7·88	−0·86	5·40	−1·43
8·95	−0·72	6·08	−1·43	2·60	−1·07	8·60	−0·87	6·07	−1·23
9·67	−1·06	6·45	−1·38	2·78	−1·08	9·33	−1·06	6·42	−1·16
10·38	−1·18	6·80	−1·61	2·96	−1·08	10·05	−1·16	6·75	−1·14
11·10	−1·19	7·15	−1·67	3·13	−1·04	10·70	−1·39	7·08	−1·11
12·18	−2·15	7·52	−1·61	—	—	11·40	−1·48	7·43	−1·12
—	—	7·88	−1·54	—	—	12·10	−1·42	7·77	−1·08
—	—	—	—	—	—	12·85	−1·42	8·10	−1·03
—	—	—	—	—	—	—	—	8·45	−0·99

In all cases $\varepsilon_3/\varepsilon_1=-(1+\varepsilon_2/\varepsilon_1)$, and for pure torsion in all cases $\varepsilon_2/\varepsilon_1=-1$ and $\varepsilon_3/\varepsilon_1=0$.

Table VI—*Complex Stress/Plastic Strain Relations for RR59 Aluminium Alloy at 200 deg. Cent. Values of Ratios $\varepsilon_2/\varepsilon_1$ and $\varepsilon_3/\varepsilon_1$ of Principal Strains*

Simple loading test, $t/s=3·72$		Simple loading test, $t/s=1·29$		Simple loading test, $t/s=0·38$		General loading test, static shear stress 2·7 tons per square inch	
Tensile stress, tons per square inch	Value $\varepsilon_2/\varepsilon_1$	Tensile stress, tons per square inch	Value $\varepsilon_2/\varepsilon_1$	Tensile stress, tons per square inch	Value $\varepsilon_2/\varepsilon_1$	Tensile stress, tons per square inch	Value $\varepsilon_2/\varepsilon_1$
6·45	−0·96	3·94	−1·86	1·52	−0·83	5·72	−0·59
7·15	−1·51	4·30	−1·38	1·61	−0·77	6·43	−0·48
7·87	−1·90	4·65	−1·35	1·70	−0·67	7·16	−0·63
8·60	−2·01	5·01	−1·29	1·79	−0·75	7·88	−0·85
9·31	−1·97	5·37	−1·30	1·88	−0·71	8·60	−1·12
10·00	−1·94	5·73	−1·33	1·97	−0·70	9·30	−1·43
10·73	−1·89	6·09	−1·37	2·06	−0·80	10·00	−1·61
11·10	−1·88	6·26	−1·44	2·15	−0·85	10·70	−1·86
—	—	6·45	−1·38	2·24	−0·88	11·50	−1·70
—	—	6·62	−1·24	2·32	−0·93	—	—
—	—	6·80	−1·24	2·42	−0·96	—	—

In all cases $\varepsilon_3/\varepsilon_1=-(1+\varepsilon_2/\varepsilon_1)$, and for pure torsion $\varepsilon_2/\varepsilon_1=-1$, $\varepsilon_3/\varepsilon_1=0$.

stress and maximum shear stress as the criterion of limit of elasticity.

Stress and Plastic Strain Relations in Simple and General Loading Tests

In what follows an effort is made to derive the stress strain relations governing the loading law (as distinct from unloading) during the progress of plastic strain.

In virtue of the fact that in all theories of plasticity loading is defined in terms of the increase of some function of the stress, those generally used being the maximum shear stress and octahedral stress, plots have been made in Figs. 1 and 3 of octahedral stress and octahedral shear strain, and in Figs. 2 and 4 of maximum shear stress against maximum shear strain for the 0·17 per cent C steel at 350 deg. Cent., and the RR59 aluminium alloy at 20 deg. Cent. respectively. Both these diagrams indicate that the octahedral stress/strain plots give a closer family of curves in each case, although admittedly this is not greatly pronounced, but is nevertheless sufficient to justify a preference for the use of the octahedral stress invariant in framing any stress strain equations. These diagrams reflect adequately the indication of corresponding diagrams for 0·17 per cent C steel at 350 deg. Cent. and RR59 alloy at 20 deg., 150 deg. and 200 deg. Cent. Accordingly the octahedral stress invariant is used in building up all subsequent stress plastic strain equations. In the previous publication (Ref. [1]) dealing with the stress plastic strain relations of magnesium alloy between 20 deg. and 150 deg. Cent. a quite full account was given of the theoretical approaches which have been made to the problem of framing stress/plastic strain relations, and there is little need to repeat this account here. The reader will be presumed to be familiar with this information.

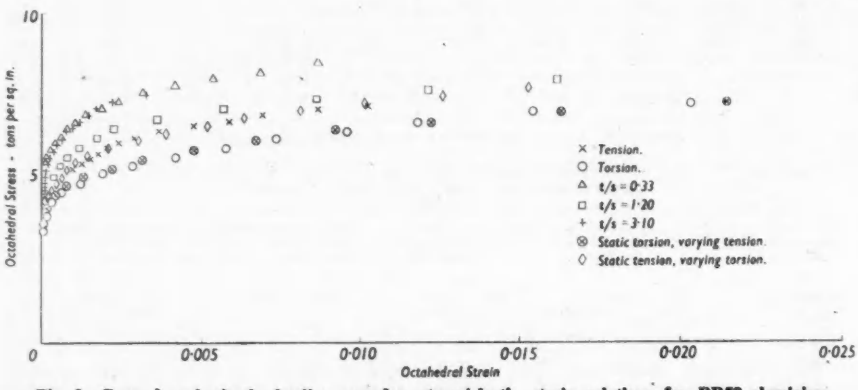


Fig. 3—General and simple loading, complex stress/plastic strain relations for RR59 aluminium alloy at 20 deg. Cent.

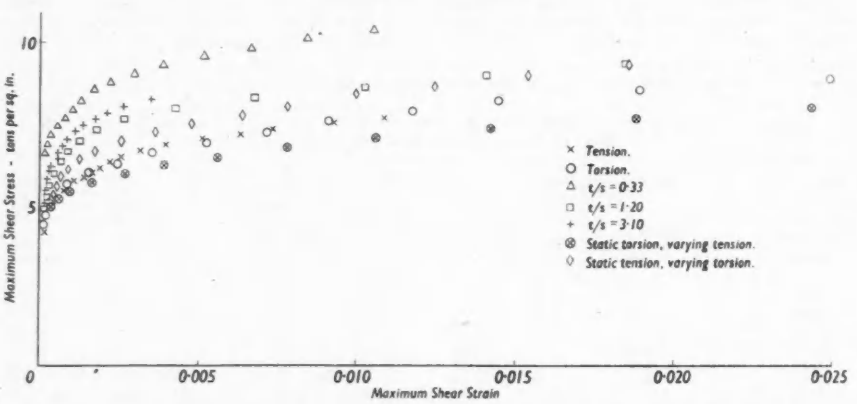


Fig. 4—General and simple loading, complex stress/plastic strain relations for RR59 aluminium alloy at 150 deg. Cent.

Consequent upon the indication that for both materials at all temperatures the octahedral stress was the criterion function of plastic strain, an examination was made by means of a series of plots of various functions of octahedral stress against functions of octahedral strain and the form of relation between the two most completely and simply representing the experimental data. These plots included a number based on the ideas of Cunningham, in which the plastic strains depended upon a function of the octahedral stress in excess of that corresponding to the limit of proportionality. It was found that, as in the case of the magnesium alloy at all temperatures, over the limited range of strain examined a linear relation between log octahedral stress and log octahedral strain held quite closely for all stress systems for both materials at the temperatures concerned, indicating a power relation between stress and plastic strain. These relations are indicated in Figs. 5 and 6 for 0·17 per cent C steel and in Figs. 7–9 for RR59 alloy. The two sets of results are discussed separately below.

0·17 Per Cent C Steel at 350 deg. and 450 deg. Cent.

It will be noted that the log log lines shown in Figs. 5 and 6 are not in any systematic order with respect to imposed stress system. It seems likely that the order is dependent largely on differences of specimen condition, and is not due to any fundamental reason, having said this attention must be focused on what is the salient point of these two plots, which is that the curves corresponding to the general loading tests at both temperatures lie within the limits of the group of curves corresponding to the simple loading tests and the tension and torsion tests, and are within the limits of experimental accuracy of precisely the same geometrical form. This form can be expressed by equations of the type $\varepsilon_0 = k\sigma_0^{2n+1}$, which is a deformation equation. Now while deformation equations cannot be strictly applied to general loading tests the above facts obviously indicate that for this material at both temperatures a set of plastic strain stress relations may be used which will agree with experimental results within the limits of reproducibility of individual tests for both simple and general loading conditions.

It must be stressed that these relations hold for loading conditions only (which in the present tests constitute an increase of ε_0 and no decrease of t or s), and are valid, of course, purely for the range of experiments undertaken. They do not indicate that representation by deformation equations to a satisfactory degree of approximation is possible outside this range. The experimental range is, however, sufficiently wide to cover many practical purposes. This is most obviously a conclusion of importance, meaning, as it does, that the performance of the material under general loading conditions can be indicated in the general sense directly from the results of simple loading tests.

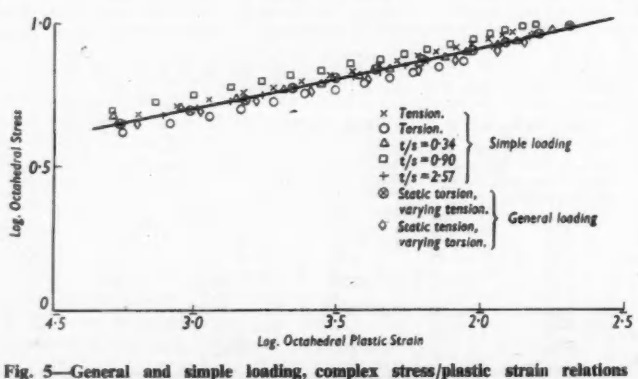


Fig. 5—General and simple loading, complex stress/plastic strain relations for 0·17 per cent C steel at 350 deg. Cent.

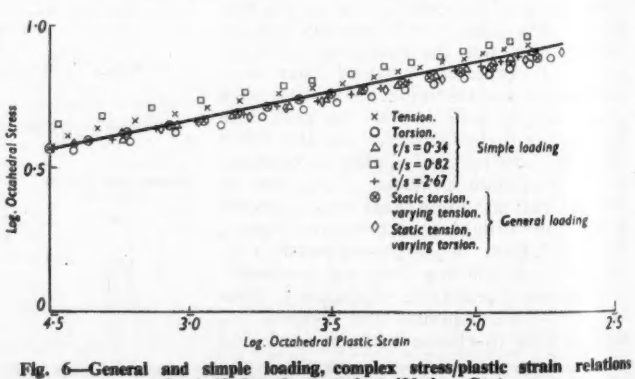


Fig. 6—General and simple loading, complex stress/plastic strain relations for 0·17 deg. Cent. steel at 430 deg. Cent.

Whether this indication is sufficiently complete to include the details of principal strain distribution is the subject of later paragraphs.

The computed characteristic of the experimental linear log octahedral stress/log octahedral strain curves reflected the random order of the test lines relative to the imposed stress systems. It is worth noting, however, that at 450 deg. Cent. four tests, including two simple loading and two general loading tests, had precisely the same mean line. In Table I the mean values of the characteristic components A_1 and n_1 are given, and the log lines corresponding to these mean values are drawn in Figs. 5 and 6 to characterise the groups of tests concerned.

From the practical point of view of the designer, the deformation form of equation is much more easily used than the incremental type. The present deformation relation in the principal plastic strain stress form for this material at these two temperatures corresponds to the linear log log plots of Figs. 5 and 6 and is, of course, of the general form :

$$\varepsilon_1 = A_1[\Sigma(\sigma_1-\sigma_2)^2]^{n_1}[(\sigma_1-\sigma_2)-(\sigma_3-\sigma_1)], \text{ \&c.}\ddagger$$

where n_1 and A_1 have the average values given in Table I and where the terms are modified to represent such anisotropy as occurs. This matter is, however, dealt with in subsequent paragraphs.

(To be continued)

Opening of V.H.F. Service by B.B.C.

We learn that the first of the B.B.C.'s new v.h.f. transmitting stations, using frequency modulation, will be brought into service at Wrotham, Kent, some 23 miles south-east of London, on May 2, 1955. The purpose of this v.h.f. transmitting station and the others now being built by the B.B.C. is to reinforce the coverage of the existing medium-wave and long-wave services, reception of which is becoming difficult for many listeners because of the increasing interference from foreign stations and from electrical appliances of various kinds.

The new station will transmit the three B.B.C. programmes, the Light Programme on a frequency of 89·1 Mc/s, the Third Programme on 91·3 Mc/s, and the Home Service on 93·5 Mc/s. The effective radiated power will be 120kW in each case, and the transmissions will be horizontally polarised. The station will serve the London area and south-east England within a range of about 50 miles.

We may recall that the B.B.C. built Wrotham in 1950 as an experimental station with two transmitters to facilitate study of the problems of high power v.h.f. transmissions and their reception. A third transmitter is now to be added in readiness for the start of the regular programme service, and the present experimental transmissions from Wrotham are suspended from March 5th to April 7th while installation work connected with the additional transmitter is in progress. To assist the radio industry and trade in the London area during this period, low-power test transmissions are being made on 93·8 Mc/s from an experimental v.h.f. F.M. transmitter at Alexandra Palace, radiating the Home Service daily from 9 a.m. until 11 p.m., approximately.

The third transmitter at Wrotham, which will carry the Home Service, differs from the two already installed in that it is built as two separate units for operation in parallel, with each unit capable of maintaining the service at reduced power in the event of a fault on the other. For the first few weeks of the v.h.f. service from Wrotham, only one of these transmitter units will be in operation, and the Home Service transmissions will not be at full power. The B.B.C. states that the effect of this is not likely to be noticeable except at extreme range.

‡ The term $\Sigma(\sigma_1-\sigma_2)^2$ is, in this case the anisotropic expression :

$$[(\sigma_1-\sigma_2)^2+B(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2]$$

The numerical value of this expression is not, however, significantly different in any given case from that of the purely isotropic expression. Use is made of this fact in framing the statement made in conclusion (3) later.

The "Automatic Factory"

By A. F. KELLEY

IF we are to maintain our standard of living in this country then the present level of exports must be upheld, but what we all want is to improve our standard of living and this means two things ; first, an increase in the volume of goods exported, and, secondly, a reduction in cost of goods for the home market.

Both these requirements mean increased output. Since the war there has been an increase in production nationally of approximately 4 per cent per annum, and it looks as though this rate of increase will continue. Examination of the reasons why the production rate increases in this manner shows that it is due partly to an increasing population and, therefore, an increase which may possibly be temporary in the working population of the country.

There has been considerable pressure nationally during recent years for a drive for increased productivity, and this has had a good effect in some considerable measure. If, however, we require to accelerate the level of national production by a rate greater than that which is now occurring, we must take a very different view of the whole problem. The obvious and most simple way of increasing production immediately is to employ more labour, but with the present level of employment this is not possible in many industries and localities.

We must therefore look to other means. The next simplest way is to apply more horsepower per man. This could lead to remarkable improvements in many industries and thus release labour for expanded production either within a particular factory or for transfer to other industries which are short of labour. This process, which has been contributing to the increase in production rate of recent years, is logically leading industrial thought to what has been described as " the automatic factory," as the culmination of the application of power to manufacturing processes.

It is well to state immediately that the automatic factory in the fullest sense of the word is not a practical reality as yet, and that if it does come to pass, its application will be limited to relatively few products which are of the requisite type and which are required in sufficient volume to justify rigid production schedules. The best example we have of automatic factories so far is in the oil refining process where science has been applied to transform a batch production process into continuous flow production by means of automatically controlled continuous processes.

There may well be a misconception that automatic factories are about to spring upon us and that the results may be alarming from the point of view of unemployment. Many fear the possibility of large-scale redundancy of labour, but there are no real grounds on which such apprehensions can be based. One of the many reasons why the productivity of the American worker is higher than his counterpart in Britain is that in America there is available approximately two and a half times the amount of horsepower per man than is available to the British worker. One of the most important advantages arising from the application of automatic production processes is an increase in the available horsepower per man, thus increasing the productivity and earning power of workers, reducing the product cost and therefore enlarging the market.

The Institution of Production Engineers is taking the examination of the factors involved in the introduction of automatic factories as the subject for its annual conference at Margate in 1955 in order to determine, even in the light of our present limited knowledge, where difficulties and dangers may be encountered and thus resolved well in advance of any possible introduction in practice. This is a far-sighted move and the discussions should prove to be of considerable interest, not only from the sociological point of view, but also from the technical point of view. In connection with the latter angle it must not be forgotten that applied science can be directed to what are termed " indirect activities " as well as to the direct processes involved in manufacture. Included in indirect activities is the work of costing and accounting to which mechanisation has already been applied and in which the use of electronic equipment is going to give the opportunity for a further step forward.

In the broader sense, an automatic factory is possibly nearer realisation, that is, in the sense that "automation"—to use the current word—can be applied to a number of existing production processes. Examples of this exist, and are being extended, in the automobile industry where components are loaded at an initial machining station and are transferred automatically between machining operations, each of which is automatically cycled.

In manufacturing industries the use of automatic plant has increased very considerably over the last fifty years. Many manufacturing operations for which the only equipment available in the early years of the century was hand operated or, at best, hand controlled are now powered and in many cases automatically controlled either by mechanisms, hydraulics or the equivalent. Examples which come to mind are the numerous tracer lathes and other adaptations of tracing mechanisms. All these, however, are cases in which individual operations only are rendered automatic ; their relationship to the succeeding and preceding operations is still under manual control even although the actual means of transportation may be on mechanised conveyors.

The designer will have a large part to play in any possible establishment of an automatic factory as the conception of the product may require to be changed to accord with manufacturing limitations imposed with present scientific knowledge. It is necessary for all of us engaged in manufacture to think in what terms we can apply similar principles, even in a small degree, in order to make the best possible use of the limited labour forces available in this country and thus to increase upward at a rate in excess of the current national average.

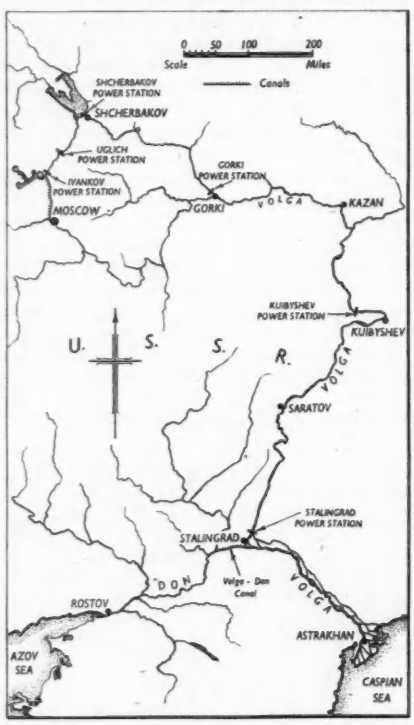
This way we will achieve a higher standard of living with probably greater leisure and greater spending power to enjoy during that leisure.

Some Commonwealth and Foreign Civil Engineering Schemes

No. II—(*Continued from page* 334, *March* 11*th*)

A brief review of some civil engineering developments in overseas countries and of their progress during 1954 *is given here. The article is complementary to "Civil Engineering in* 1954," *published in January, in which works carried out by British civil engineers in* 1954 *were reviewed.*

IN 1952, the Volga-Don canal project in the U.S.S.R. was completed. This very large scheme was, we understand, the first in Russia on such a scale, which made use of modern plant and methods of construction. It was used as a training ground to build up a nucleus of experienced engineers and tradesmen, and to try out constructional methods for future works. Thus the several large projects under construction in 1954 were, to one degree or another, based upon the methods and experience of this earlier work. The Volga-Don canal is 107km in length, with four locks rising 44m above the Don, and a ladder of locks descending 88m to the Volga. There are three reservoirs spaced along the canal, which are replenished by pumping stations. The largest reservoir of the scheme is a fourth one, the Tsimlyanska reservoir, on the Don, formed by a barrage and power station, where the power supplying the pumping stations is



Multiple-purpose river development projects on the Volga River

generated. The power station has an installed capacity of 160MW, a spillway apparently of 20,000 cumecs capacity, and the reservoir stores nearly 20,000,000 acre-feet, some of the water being used for irrigation. Large mechanised central concrete mixing and batching stations were used in the construction of the scheme, with a great deal of excavating plant, on familiar Western lines, and including a 20 cubic yards walking dragline for canal excavation. The barrage was built from a central steel gantry carrying travelling cranes, and along which concrete trains were run, the concrete being placed by the cranes. The gantry steelwork was built into the permanent structure and was then utilised again, we understand, for carrying the sluice gates. The barrage and locks involved much heavy reinforced concrete work, reinforcement being welded into prefabricated assemblies ; the locks were faced with large precast concrete slabs. A large earth dam was built by placing the fill hydraulically.

Many of these constructional features were repeated in the works under construction in 1954. The accompanying map shows the projects on the Volga River. The three north of Moscow—Scherbakov, Uglich and Ivankovo are old schemes, but the three further downstream at Gorki, Kuibyshev and Stalingrad, were all under construction last year. They are multi-purpose schemes, providing flood control and irrigation, as well as generating hydro-electric power, and including locks for navigation of the river.

The Gorki project involves an earth dam 18km long, with 16,000,000 cubic metres of fill. The first concrete of the project was poured in April, 1951, and the power station was due to be on load by the end of last year. The head of the scheme is 18m and it includes a navigation canal 2·3km in length with two two-chamber locks. Unfortunately we have no figures for the power output of the scheme.

The two lower stations shown on the map will each generate about 10,000 million kWh annually, the ultimate installed capacities being 2100MW at Kuibyshev and 1700MW at Stalingrad. These figures will place them amongst the largest hydro-electric schemes yet built. The Kuibyshev project involves an earth dam 4km long, with a concrete section incorporating the power station and spillway with a length of 1km. The earth dam has a maximum height of 40m and the spillway section 35m. We illustrate the construction of the spillway and power house section, which is shown at a fairly early stage ; the erection gantry, is 35m high. The travelling cranes with their counter-balanced jib at the top of the main jib are typical of contemporary Russian construction of this kind.

Construction gantry of the Kuibyshev project in the U.S.S.R.

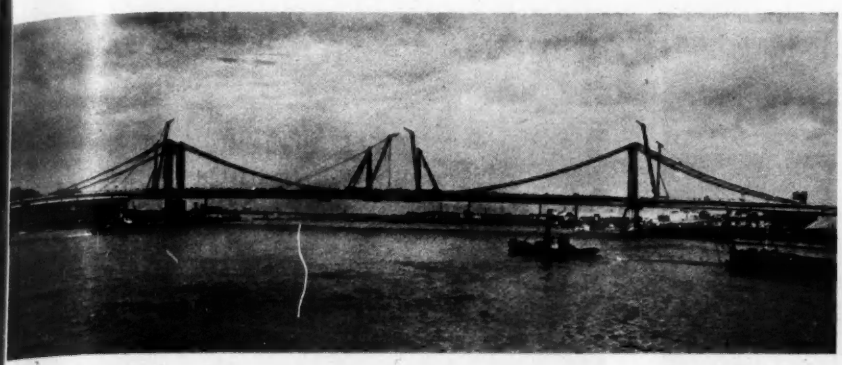
Construction of the Kuibyshev project was started in 1950, and power is expected from it this year, with the locks in service by the spring. During 1954 construction of the spillway and power house was in full swing, and concrete was placed, we are informed, at a rate of 15 to 18,000 cubic metres daily in the midsummer period. A total of 1,568,000 cubic metres was poured in the first ten months of the year, the total quantity involved in the work being 7,000,000 cubic metres. A particular problem of the scheme was, apparently, the closure of the Volga, the estimated flow being about 8 to 10,000 cumecs ; this problem has been the subject of an intense hydraulic study. The power station is to contain twenty turbo-alternator sets, each giving 108·5MW at minimum flow, we are informed, and 126MW at the normal head of 22·5m. The reservoir will extend over 5760 square kilometres.

The multi-purpose project at Stalingrad is on a similar scale to the Kuibyshev project and will have seventeen turbo-alternators installed in its power station. The turbines at these projects are presumably Kaplan machines, the diameter of the runners of the Stalingrad machines being given as 9·5m. The Stalingrad scheme is due to yield power in 1956 ; its head will be about 25m.

We are informed that about 60 per cent of the power generated at these new stations will be transmitted at a voltage of about 400kV, along long distance transmission lines to Moscow, where there is a shortage of power for existing industries. But the local benefits given by the schemes, particularly from irrigation (the pumping stations of the irrigation works make quite a substantial call on the power output) will be considerable.

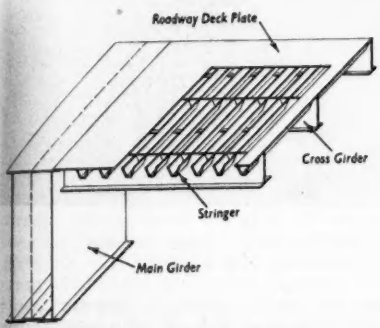
Another large Russian river—the Dneiper—was also being developed during the year, in its lower reaches at Kakhovka. Here a dam 4·7km in length was under construction ; the main object of the scheme is irrigation, but it includes a 250MW power station, which will yield 1200 million kWh annually, it is estimated. This scheme also made use of the same basic layout in its design, and of the same constructional techniques. About 700,000 cubic metres of concrete were placed during the year and 5,000,000 cubic metres of fill were placed in the dam.

The Kama power station, on the Kama River, a tributary of the Volga, in the Urals, is of interest since it is to have twenty-four turbines installed in the spillway section of the dam, thus



Bridge over the Rhine between Duisburg and Homberg just before its completion

obviating the construction of the power house. The flow utilised here is 1700 cumecs, the head 20m, and navigation locks and a 1·5km canal are to be built. Other projects under construction in 1954 included the Mingechaur scheme in Azerbaijan, which, we are informed, will irrigate 5,000,000 acres, and a number of schemes in Siberia. A " cascade " of projects is planned on the Ob River in Siberia, of which the first is being built at Novobirsk, where work started in 1951. The flow here is 4400 cumecs and the head 24m. Here also earth dams are involved totalling



Lightweight steel deck structure of the Homberg-Duisburg suspension bridge

5km in length and requiring 8,000,000 cubic metres of fill, and navigation locks are being built.

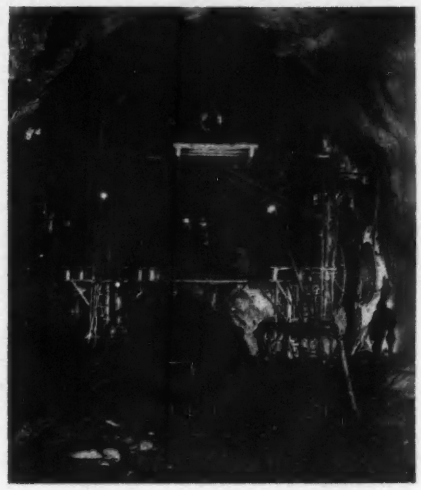
Two German Suspension Bridges

Last December, two important suspension bridges, built across the River Rhine in Germany, were opened to traffic. Both are road bridges. The Cologne–Rodenkirchen bridge replaces a similar structure demolished during the war, and it utilises the piers and towers of its predecessor, which was built in 1941. The main span of the Cologne–Rodenkirchen bridge is 378m—which is thought to be the largest suspension span in Europe—and the two side spans are each of 94·5m ; in cross section there are two 8·7m carriageways with a central reservation of 2·86m, and two 3·07m lanes outside the carriageways.

One of the problems of constructing this bridge was to ascertain how much of the former bridge was still capable of being repaired. Surveys of the piers showed that settlement had occurred, but after certain repair works were done, they were considered satisfactory for re-use ; the new steelwork of the superstructure, however, weighs only 3100 tonnes, as against 6000 tonnes of the former bridge. The towers of the old bridge were standing, but were twisted, due to displacement of their feet ; for instance, the west pier (its axis is roughly north-south) had its north foot displaced 37cm westwards, and its south foot displaced 20cm eastwards. The tower, which weighs about 1600 tonnes and is nearly 60m in height, was jacked on to rollers, and restored to its original position. A similar procedure was carried out on the southern tower. The old anchorages were tested to a 400-tonne load, applied by hydraulic jack (they carry 150 tonnes each, and carried 300 tonnes during construction) before incorporation in the new bridge.

The design loading on the new bridge was according to the German DIN 1072 specification, which permitted a reduction in the total of 400 kg per square metre allowed for the old bridge, but allowed for increased local concentrations of load. The cables comprise sixty-one ropes of 54mm diameter (each of 1095 square millimetres cross section and 16 kg per metre weight) with a 35 per cent reduction in weight over the previous structure. The principal stiffening girders are I-shaped, with a depth of 3·3m ; secondary and tertiary steel beams carry a prestressed concrete deck slab, which is continuous for the full length of 570m, and involved the use of special shear connectors. The firms concerned with the bridge were A. Klönne, Dörtmunder Union Brückenbau and M.A.N.

The second bridge, which we illustrate herewith at an advanced stage of construction, crosses the Rhine between Duisburg and Homberg. It has a central span of 285·52m, two side spans, each of 128·3m, and a flood relief opening on the Duisburg side of 55·8m ; its width is 24m. A saving of about 1000 tons in a total weight of 6920 tons is claimed for the superstructure of the bridge, by the introduction of two constructional novelties. The cables and hangers were pretensioned during erection so that the stiffening

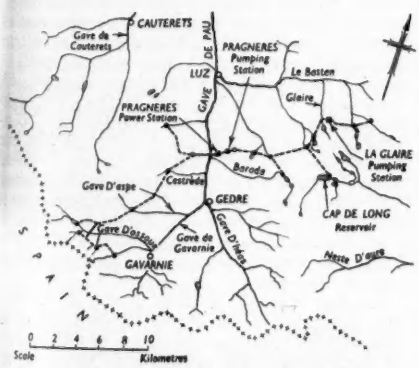


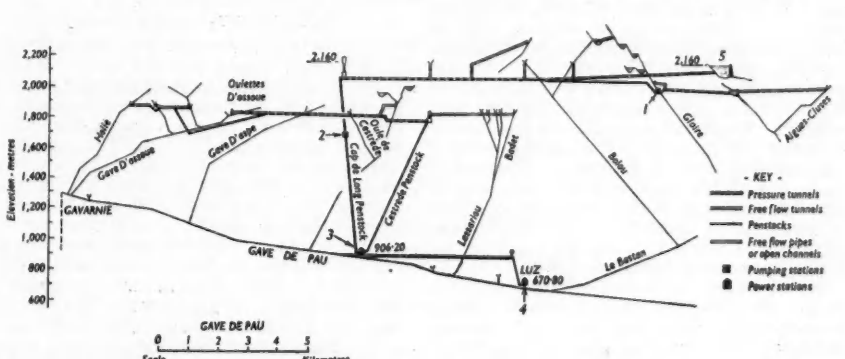
Drilling jumbo with fourteen drills used for the construction of the Isere-Arc tunnel

girders are free from bending stresses due to dead load, and the roadway is of a flat plate construction with box stringers, as illustrated in the diagram. The designers point out that the decking plate acts as an upper flange for the cross girders and box stringers, and also resists shear loads ; this construction behaves anisotropically in the two main directions. A roadway slab weighing 31 lb per square foot was used with this construction. The Duisburg-Homberg bridge was designed and built by Demag. A.G.

Hydro-Electric Power in France

During 1954, hydro-electric construction in France was much less than in previous years, and the position has been described as an obligatory pause between two programmes of new construction ; with the amelioration of the desperate power supply conditions just after the war, less capital has been allowed, of late, for new projects, and the civil engineering resources serving the industry were thus not fully occupied.





1—Pumping station of La Glaire. Two 3000 h.p. pumping sets, each giving 0·85 cumecs with 140m head. Maximum capacity 2·9 cumecs ; annual power consumption 10×10^6kWh ; annual yield 24×10^6 cubic metres.

2—Pumping station of Pragnères. First stage installation : two 14,000 h.p. sets, each giving 2 cumecs with 400m head. One 7200 h.p. set, giving 1 cumec with 400m head ; maximum capacity 6·2 cumecs ; annual power consumption, 30×10^6kWh ; annual yield, 24×10^6 cumecs.

3—Pragnères power station. Installed capacity 200,000 h.p. Two horizontal shaft Pelton wheel turbo-alternator sets, each with two single-jet turbines, each of 80MVA. Head, 1150m ; rated flow of each set, 7·3 cumecs ; gross annual energy output, 375×10^6kWh.

4—Luz II power station. Two 29,300 h.p. turbo-alternator sets. Head, 229·2m ; rated flow, 21 cumecs ; annual output, 100×10^6kWh.

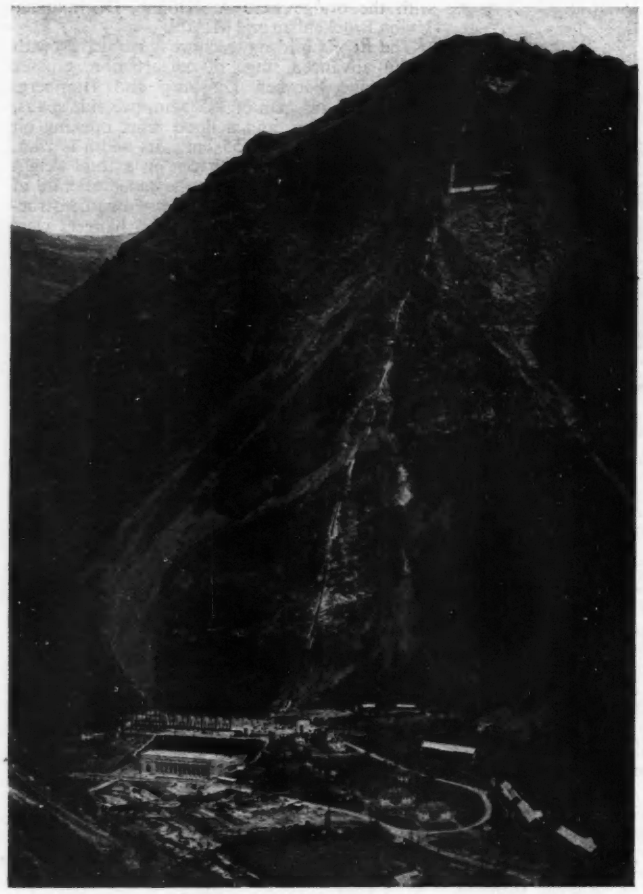
5—Cap-de-Long reservoir. Storage capacity 67×10^6 cubic metres (nearly 56,000 acre-feet) ; thick arch dam, 100m high ; concrete volume, 270,000 cubic metres ; top water level, 2160m above sea level.

Statistics for whole scheme (excluding Luz II section) :

Total length of tunnels	40km
Total length of shafts...	770m
Steel penstocks and pipes	8·8km
Concrete pipes	5·7km

Preliminary works included eighteen ropeways and five inclined railways, with a total length of 3400m, and 33km of new roads and tracks.

Layout of the Cap-de-Long and Pragneres development in the Hautes Pyrenees



Pragneres power station, showing the main penstock supplying 200,000 h.p., and of 1150m head. The pumping station may be observed on the mountain side

Cap-de-Long dam of Electricite de France. The dam is a thick arch structure 100m in height

Nevertheless, some interesting works were in progress. In a series of articles published in THE ENGINEER in November and December, 1951, the hydro-electric exploitation of the Isère River was described. One of the projects mentioned in that article was then in its early stages and involved construction of a tunnel under conditions not encountered for about fifty years, since the Lotschberg tunnel in Switzerland had been completed. This tunnel—of the Isère-Arc project—was put into service in March, 1954; it was driven 11·7km between points of access, under a crystalline massif, with an overburden of 2000m above the tunnel at one point. The tunnel is 43 square metres in cross section, and problems of temperature, ventilation and decompression of the rock had to be faced, as they were at the Lotschberg tunnel fifty years ago. It took four years to drive the tunnel, using a full-face system of working, with a jumbo equipped with heavy drills, illustrated herewith, and two "Conway 75" loaders working side by side, with electrically driven 4 cubic metre skips to take out the excavated material. The tunnel was concreted immediately following the progress of the driving, using a high-capacity plant based on a "Pressweld" placer. In the downstream section, a change in the rock conditions made it necessary to change to pilot tunnel construction. Twelve metres progress was recorded in one day's driving, the maximum monthly figure being 274m.

It will be recalled that the project utilises a length of the Isère regulated by the Tignes reservoir, taking water from the Moutiers project at a level of 471m above sea level, and returning it to the Arc at a level of 319m; the Arc rejoins the Isère 10km further downstream. The intake of the scheme comprises a barrage 20m in height, with two 10m ground sluices with sector gates which allow solid material to be scoured down the river. The diversion works total 17km in length, and before the tunnel is reached a reinforced concrete conduit 6m in diameter and 2·5km long carries the diverted water. Telescopic centering was used to build the conduit, which was cast in 10m rings on a base of weak concrete. Reinforcement was welded and the joints of the conduit were made watertight with bands of bituminous felt.

The surge chamber of this scheme is of imposing dimensions; it is 50m high and 18m in diameter with two upper expansion chambers. Two vertical shafts, each 3·7m in diameter and 120m in depth, lead from this point to the underground power station, where there are four 36MVA vertical Francis turbo-alternator sets. Two 72MVA 10·3/150kV transformers are also installed underground. The tail-race of the scheme includes about a kilometre of open channel, with its side slopes formed of precast concrete slabs. The scheme will produce about 450 million kWh annually, its gross head being 152m and the maximum flow 200 cumecs.

Developments in the Pyrenees

An important seasonal reservoir completed by Electricité de France in 1954 in the Hautes-Pyrénées was the Cap-de-Long reservoir, which is associated with the Pragneres power station in the upper catchment of the Gave-de-Pau River, between Lourdes and Gavarnie. The reservoir is 2160m above sea level and is supplied by an extensive system of collecting aqueducts and pumping stations, for it has been built in a catchment where a suitable site for a large reservoir was difficult to find. The way in which this single reservoir collects the water from a considerable catchment is clearly shown in the accompanying plan and section of the project. The principal data for the scheme are given in the legend.

The main tunnel from the reservoir to the power station is 10km in length, and is used to collect the flow from the aqueduct tunnels in the right bank system. The maximum head in the tunnel is 120m. As may be observed, most of the right bank intakes are above the top water level of the reservoir, but those below are served by the Glaire pumping station. On the left bank, however, the intakes are generally at about 1850m. The left bank system terminates in a penstock, on the left bank slopes, which leads down to the head race of the power station, where it connects with the main penstock from the right bank system. This main penstock has a pumping station, built on the cliff face, which pumps the left bank waters, for the topmost 400m, into the Cap-de-Long reservoir when the power station is not in operation.

The scheme is an important one with a gross annual output of 475 million units, including the power station of Luz II, which will utilise the head from Pragneres power station to the existing installation at Luz (which is at the head of a cascade of power stations in the Gave valley); the Cap-de-Long reservoir has a storage capacity equal to a third of the energy resources of French power stations in the Pyrénées. A further 180 million kWh can be obtained, it is estimated, from future extensions of the scheme.

Some of the more interesting technical problems included the arrangements for preventing air entrainment at the side-stream intakes, the hydraulic layout of the Glaire pumping station, and the installation of a pumping station of such large capacity as the Pragneres station. The right bank penstock (the French "autofrettage" construction is used) has a capacity of 200,000 h.p. in a single pipe, which is thought to be a record figure. The head of the scheme is the highest in France, except for that of the Portillon scheme (1450m), also in the Pyrénées. Work on the scheme started in 1947, and the left bank diversion and the Pragneres pumping station are expected to be in service this spring.

Another interesting development in French hydro-electric practice during 1954 was the completion of the small power station at Castet, also in the Pyrénées, on the Gave d'Ossau River. Here, a "monobloc" turbo-alternator, as it is called, was installed; this design is intended for low-head or tidal schemes, and a saving in cost of 40 per cent over a conventional installation is claimed. The complete set is installed below water level in a well in the barrage, thus eliminating the conventional power station. A description was given in our issue of October 29th last.

(To be continued)

Method of Heating Control

By D. A. SENIOR, M.A., A.M.I.E.E.*

No. I

A new method of controlling the temperature of a rotating drum in photographic processing is described. The drum takes the form of a metal spinning which runs on three rollers and is linked with a transformer. The short circuit current gives rapid heating, whilst the temperature is controlled by monitoring the current taken from the supply which falls as the drum warms up. How the transformer is designed to suit the purpose of the device—in the present case to develop and dry photographic paper records—is described, the characteristics of spinnings of various metals are considered, and conditions are deduced for minimum weight, maximum heating capacity and most rapid warming-up.

THE method of heat control described here originated during a search for practical means of rapidly processing photographic records. An elegant and simple method has been devised by the Research Laboratory of Kodak, Ltd.[1] The method can be used with records on paper, though not on film, and has come to be known as hot drum processing. Its advantages are that it enables the records to be examined within a few seconds of exposure and handled in a dry condition less than half a minute later. This is achieved as follows : before exposure to light the photographic paper is passed through a bath of developer which is kept quite cold and, therefore, does not deteriorate. Excess liquid is removed by a squeegee and then the paper passes on to a hot drum. Just before it reaches the drum, exposure takes place ; in the original Kodak model the light beam from the recording unit—a cathode ray oscilloscope—was focused on the paper at the point where it met the drum. Development and drying both occur on the drum and the record, though not fixed, is sufficiently stable to be handled even in sunlight for several hours. Traces to be kept for reference are fixed and washed in the usual way.

Since 1950, when the first experimental model was demonstrated at the Physical Society Exhibition, there have been a number of attempts to produce a processer suitable for laboratory or field use. Difficulty has always been encountered, however, in maintaining the temperature of the drum when long lengths of paper are processed. If conventional methods of heating are employed, a heavy drum must be used. Otherwise the drum cools off in operation and soon fails to give adequate development and drying. This involves a long "warming-up" period and even if the delay is accepted, difficulty then arises in maintaining adequate temperature control. For, in addition to the troubles which arise when the drum becomes too cool, too high a temperature leads to poor trace definition and scorching of the paper.

A solution to the problem is to make the drum as light as possible so as to minimise its thermal capacity, to supply ample power so as to heat the drum rapidly both during warming up and in operation, and to control the temperature by means of a very quick-acting thermostat. There seems to be no way in which the usual methods of heating and temperature control can meet these requirements ; the novel method which will be described has, however, been successful. It is described in this journal because it seems to the writer that the applications of the technique may well extend beyond the purpose for which it was originally devised.

Thermal capacity is minimised by making the drum serve as its own heating element. The drum takes the form of a copper spinning (see Fig. 1), which is arranged to form the short circuited, single-turn secondary of a transformer. A heavy current flows in the drum and rapidly raises, or restores the temperature to the operating value. The drum is mounted on rollers, so is free to rotate and carry the photographic paper.

Temperature control utilises the increase in the electrical resistance of the drum as its temperature rises. The increase in resistance leads to a reduction in the current taken from the supply which is monitored by a simple electronic circuit. When the current has fallen to the value appropriate to the operating temperature, the power supply is interrupted for a few seconds. The power is then restored and the drum again brought up to temperature. In this way the processing temperature is controlled within close limits.

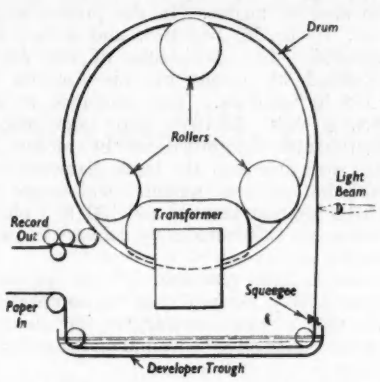


Fig. 1—Layout of rapid processing machine

The Basic Circuit

The circuit is shown in simplified form in Fig. 2. The primary of the transformer T, of which the drum forms the secondary, is fed from 230V, 50 c/s, mains via a resistance R_1, and the normally closed relay contacts A_1. The potential across R_1 is proportional to the primary current of the transformer, and from it is subtracted the potential across R_2, which is proportional to the mains voltage, but is arranged to be nearly in phase with the potential across R_1. The difference between the two potentials is amplified by the valve V_1 and rectified, the rectified voltage appearing across the condenser C_1.

As the temperature of the drum rises after switching on, the current in R_1 falls and so does the difference between the (a.c.) potentials across R_1 and R_2 and also the (d.c.) potential across C_1. Initially, this potential is greater than the positive bias provided by the resistance R_3, so that the valve V_2 is not conducting. The bias is arranged so that when the appropriate drum temperature is reached, the valve V_2 begins to conduct and energises the relay A which is included in its anode circuit. The relay contacts A_1 then open and interrupt the primary current of the transformer. The contacts A_2 change over connecting the condenser C_2 between h.t. positive and the grid circuit of V_2. Since C_2 is initially discharged, the grid of V_2 would be taken almost to the potential of the h.t. supply, but for the grid stopping resistance. The valve V_2 passes the saturation current holding on the relay until the condenser C_2 has charged sufficiently for the potential across C_1 to overcome these across R_3 and R_4. The valve V_2 ceases to conduct, the relay A is no longer energised, the contacts A_1 close, reconnecting the transformer to the supply, and the contacts A_2 change over so that the condenser C_2 is discharged through the resistance R_5. The drum is then heated again until the operating temperature is reached, when the transformer supply is again interrupted. This procedure is repeated, the power being switched off for a few seconds every time the operating temperature is reached.

A third set of relay contacts is involved. The contacts A_3 substitute the higher resistance R_7 in place of R_6, during the time the relay is energised, and so reduce the potential across C_1 to a suitable value. If this is not done, interruption of the current in R_1 leaves the potential across R_2 as the sole input to the valve V_1 and this is too great. The change is made at this point in the circuit rather than at the grid of V_2 in order that the potential across C_1 be as near as possible to its operating value at the instant when the power is restored. This minimises the time delay whilst the circuit "finds" what the drum's temperature is.

The Circuit in Practice

The h.t. supply is taken from the mains via a "6X4" rectifier. Resistance capacity smoothing is used, some of the supplies being taken from the fully smoothed and some from the partly smoothed h.t. The valves V_1 and V_2 of the circuit shown in Fig. 2 are the halves of a "12AT7" double triode. The bias circuit which determines the operating temperature incorporates a "Metrosil"† resistance in order to compensate for fluctuations in supply voltage. (The operating temperature changes by only a few degrees when the mains voltage varies between 210V and 240V). The resistance R_1 is mounted externally to the temperature control unit. As it must dissipate about 7W and quickly settle down to its operating temperature, it is constructed from "Eureka" resistance wire wound on an open "Tufnol" former. The relay A of Fig. 2 is a 6500-ohm Post Office relay. Contacts A_1 are operated

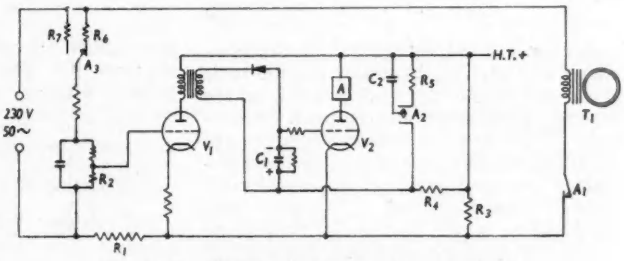


Fig. 2—Simplified circuit of temperature control unit

*Admiralty Research Laboratory, Teddington.

† "Metrosil" is a material which was developed by Metropolitan-Vickers Electrical Company, Ltd. and exhibits a non-linear voltage-current characteristic.

by a robust slave relay external to the main control unit. High stability sputtered carbon resistances are used in all critical parts of the circuit. No electrolytic condensers are used.

The timing circuit is, in fact, somewhat more complicated than the one which has been described. When power is restored at the end of the hold-off period, an interval of rather less than one second must elapse before the power can be cut even if the drum temperature is already high enough. When the machine is idling and no development is occurring, the heat losses are small. Consequently, the drum temperature increases slightly each time power is supplied and the temperature creeps up to a higher value at which losses are greater. This can be avoided by simply increasing the hold-off period. If this is done, however, too great a temperature drop occurs during the hold-off period when development is in progress. The hold-off period is therefore arranged to vary with the hold-on period, but in the opposite sense. When relay A operates, the condenser C_2 is discharged through the resistance R_5 as before, but the slave relay then operates and connects condenser C_2 through a resistance to a source of potential. Thus, the condenser C_2 slowly recharges during the hold-on period. If this period is long C_2 is almost fully charged by the time it is connected to the grid circuit of V_2, so the hold-off period is small. If the hold-on period is short, C_2 is almost uncharged, so takes longer to charge when connected in the V_2 circuit. In this case, the hold-off period is longer. When this discharge-recharge circuit is included, the hold-off period varies from five seconds when the machine is idling to rather less than one second when processing is taking place.

Drum Materials

The first problem is to choose the most suitable material for the drum. The weight and warming-up time depend on the material used. The weight of a drum of given diameter, width and electrical resistance is proportional to the product of the specific resistance and specific gravity of the material; the warming-up time is proportional to the product of weight and specific heat. A number of materials are compared in the table.

Weight and Warming-up Times of Drums Formed from Various Metals

Material	Weight	Warming-up time
Copper	1·0	1·0
Aluminium	0·5	1·06
Silver	0·99	0·61
Brass	3·8	3·65
Phosphor-bronze ...	3·3	3·0
Iron	10·0	5·9

A copper drum is used in the processer which will later be described, but the table shows that aluminium and (apart from the expense) silver could also be used. Aluminium would give the lightest drum but the advantage is not a great one since the transformer core and winding are considerably heavier than the drum. A silver drum would be no heavier than one of copper and would heat up in two-thirds of the time.

Transformer Design

The second problem is to design a transformer which will deliver sufficient power to the drum. This involves the power required and the resistance and inductive reactance of the drum. The resistance of the drum is readily calculated from its dimensions and the specific resistance of copper, making allowance for the increase brought about by cold working during the spinning process. A value of $1{\cdot}85\ 10^{-6}$ ohms per centimetre cube gives values which best agree with experimental determination. The resistance is $226\ 10^{-5}$ ohms for a 10in diameter drum with ½in flanges and weighing 1 lb.

The inductive reactance of the drum may be calculated by means of the approximate

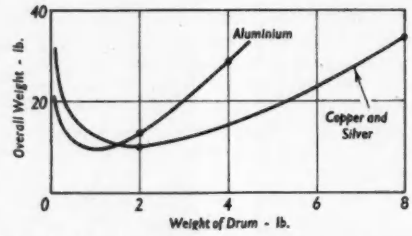


Fig. 3—Overall weight of the transformer and drum as a function of the weight of the drum

formula† for the inductance of a short solenoid :—

$$L=\frac{8\ 10^{-6}\,.\,T^2D^2}{3{\cdot}5D+8l}\ .\ \frac{D-2{\cdot}5d}{D}\ \text{henries},$$

where T is the number of turns, D the external diameter, $(D\text{-}2d)$ the internal diameter and l the length. Dimensions are measured in metres. In the present case, $T=1$, $D=0{\cdot}254$, $l=0{\cdot}076$, and d may be neglected. The inductance of the drum calculated by means of this formula is $0{\cdot}345\ 10^{-6}$ henries. The reactance at 50 c.p.s. is thus $110\ 10^{-6}$. (For comparison, experimental determinations by means of tests with drums of the same diameter and width but different weights yield values of $115\ 10^{-6}$ ohms resistance and $130\ 10^{-6}$ ohms reactance. This includes the primary leakage reactance.)

The leakage reactance of the primary winding may be neglected in comparison with that of the secondary so the number of turns which must be wound on the primary

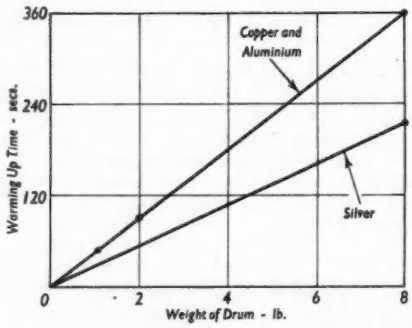


Fig. 4—Warming-up time as a function of the weight of the drum

can readily be calculated from the power required W. The current flowing in the primary winding, neglecting the magnetising current, is :—

$$I_p=V/\{(R_p+R\rho^2)^2+(X\rho^2)^2\}^{1/2} \quad . \ . \ (1)$$

The heating of the drum is :—

$$W=I_p^2R\rho^2=V^2R\rho^2/\{(R_p+R\rho^2)^2+(X\rho^2)^2\}^{1/2} \quad . \ . \ . \ . \ . \ (2)$$

where V is the potential across the primary winding, ρ the number of turns on the primary, R the resistance of the drum, X its reactance, and R_p the resistance of the primary.

The design of the transformer is derived from equation (2) and the variables will be considered in turn. The power requirement W is determined by the rate at which developer must be evaporated and by the heat loss. The evaporation rate is determined by the area of paper processed in a given time (the product of paper width and paper speed), and the amount of developer for a given area of paper. This amount is arranged to be the minimum consistent with adequate density of the record. Heat losses depend on the ventilation rate which is adjusted to be the minimum so long as the paper is dried (air movement is controlled by a small extractor fan). There is some latitude since the temperature of the drum and the time during which the paper lies on the drum are also involved. One of the aims in the design is to make the drum small and light. Drying is most rapid and the drum therefore smallest if temperature and ventilation rate are high. The upper temperature limit for satisfactory development is around 130–140 deg. Cent., whilst increasing the ventilation rate increases heat losses and so makes the transformer heavier. The present design compromises by making heat losses equal to about one-quarter of the evaporation losses. The drying rate is the critical factor since development occurs within a few seconds.

The reactance of the drum X is determined by its dimensions (diameter and paper width). The diameter of the drum is a function of the required paper speed, and the rate of drying of the paper which is itself dependent on the ventilation rate. A speed of 1in per second can be achieved with a drum 5in in diameter, so the speed of operation of the present machine could probably be increased to 2in per second by increasing the ventilation rate and power input (the design envisaged a speed of 2in per second, but power requirements could not be gauged accurately before the machine was built).

The resistance of the drum R depends on its width and diameter, and on the thickness of the copper sheet which forms it. This thickness determines the weight of the drum and (with a given power input W) the warming-up time.

The design procedure is therefore as follows :—

(1) Given the width of the paper and the speed at which it is to be developed, find the minimum size of drum which will achieve this speed without undue heat losses in ventilation.

(2) Determine the power required to ensure drying of the paper and make good the heat losses.

(3) Select the gauge of metal for spinning the drum so that the weight of the drum and transformer is a minimum. (The gauge must, of course, be such that the drum is not mechanically weak.) The cross-sectional area of the core of the transformer is derived in this calculation.

(4) Calculate the thermal capacity of the drum and its warming-up time. (The heat loss by ventilation may be ignored for this purpose.) If the warming-up time is too great, a lighter drum must be used and a greater overall weight accepted.

(5) From the dimensions of the drum calculate its resistance and reactance by means of the formula given, and hence the number of turns on the primary and the primary current.

(6) Determine the primary wire gauge to carry this current. To minimise weight, the primary copper loss in the processer to be described is high by usual standards. (High temperature materials are used in the construction.)

(7) From the dimensions of the primary winding calculate the dimensions of the

† Due to J. H. Reyner, *Electrical Engineer's Reference Book*. Section 1, page 51.

transformer core (the area of cross-section is already known).

Items (1) and (2) call for experimental determination. Experience with the present machine shows that a 10in diameter drum and a power of 500W will develop and dry 70mm paper at 1in per second. A speed of 2in per second could probably be achieved by increasing the power input to 1000W. Further speed increase would require a drum of greater diameter.

Design for Minimum Weight

The optimum drum weight is not a simple function of the other variables, but approximate formulæ can be derived and a graph plotted. Consider the resistance of the drum as the independent variable. The weight of the drum varies inversely as its resistance. The area of cross-section of the wire composing the primary may be taken as proportional to the primary current I_p; the length of the winding may be taken as proportional to the number of turns, since the number does not vary greatly over the region of interest. The weight of the primary winding is thus proportional to the product

$$\rho \times V/\rho^2(R^2+X^2)^{1/2}.$$

But from equation (2), neglecting R_p and the magnetising current,

$$\frac{V}{\rho}=\left\{\frac{W(R^2+X^2)}{R}\right\}^{1/2} \quad . \quad . \quad . \quad (3)$$

Substituting this value of V/ρ, the weight of the primary winding is proportional to $(W/R)^{1/2}$ or, since W is constant, to $(1/R)^{1/2}$. The weight of the iron core of the transformer is nearly proportional to $A^{3/2}$, where A is the cross-sectional area, i.e. proportional to $(V/\rho)^{3/2}$ or $\{(R^2+X^2)/R\}^{3/4}$.

In the present design the core weighs 6·7 lb, the drum 2·0 lb, and the winding 3 lb. The formulæ just derived have been used to calculate the weights of drum, winding and core for various values of the resistance of the drum R. The overall weight is plotted as a function of the weight of the drum in Fig. 3. The warming-up time is given in Fig. 4. Copper, aluminium and silver drums are considered. The graphs show that the minimum weight is achieved with a 2 lb copper or silver drum or a 1 lb aluminium one.

A close approximation to the optimum can be derived by minimising the weight of the transformer core only, for at the optimum the core weight is considerably greater than those of drum and winding and exhibits a minimum, whereas the other weights rise steadily as the resistance of the drum is decreased. It is readily seen from equation (3) that V/ρ is a minimum when $R=X$. The calculated reactance is 110 10^{-6} ohms and the resistance of a 1 lb copper drum 226 10^{-6} ohms. The drum should thus weigh 2 lb for minimum overall weight.

Design for Minimum Warming-up Time

Figs. 3 and 4 show that by using a copper drum weighing 0·5 lb the warming-up time can be reduced to 22·5 seconds at the expense of a 3 lb increase in weight. The time could be reduced to eleven seconds but this would involve a weight increase of 10 lb and the drum would have a wall thickness of 0·0075in and probably be weak mechanically.

Design for Various Drum Dimensions and Heating Capacities

There is no effective limit to the heat which can be generated in systems of this type, though for very high powers the circuit breaker, which interrupts the power supply at intervals, and the transformer might be somewhat heavy. It is understood, however, from the English Electric Company that "C" type cores can be produced to non-standard dimensions up to quite large sizes, so the construction of suitable transformers should present little difficulty. The size of the electronic circuit is independent of the power which is controlled.

The maximum heat output of a given drum is readily derived from equation (3). The quantity V/ρ, the volts per turn, is proportional to the cross-sectional area of the iron core of the transformer. The maximum heat is generated when R is equal to X. Thus if the maximum heat is W_{max}, then

$$W_{max} \propto A^2/X \quad . \quad . \quad . \quad . \quad . \quad (4)$$

where A is the cross-sectional area of the iron and X the inductive reactance of the drum.

For a given drum, the heat generated goes up with the square of the iron cross-section. With the drum employed in the present machine, the cross-section is 2 square inches, but if the primary winding were located outside the drum the area could be, if desired, increased to that of a square of diagonal 9in, i.e. about 40 square inches. The secondary leakage reactance would be reduced by the presence of the iron, but even if it were to remain the same, a sufficiently massive transformer would theoretically deliver a power of 200kW to it.

If the diameter of the drum is large in comparison with its axial length, the inductive reactance is roughly proportioned to the diameter. For a given transformer core the maximum power W_{max} is seen from equation (4) to vary inversely with the reactance, i.e. inversely with the diameter. On the other hand, the possible iron area A goes up with the diameter squared so the maximum power which can be delivered is proportional to the diameter. The maximum watts per square inch of drum surface is thus independent of drum diameter. The figures are very rough, but indicate that there should be no lack of heating capacity for even heavy equipment.

Drums with thick walls, or drums long axially in relation to their diameter, could not be formed by the spinning process. A well-made seam, however, would not impose enough added resistance to cause local overheating, so there are no obvious difficulties in making transformers or drums of any reasonable size.

Reference

[1] *J. Sci. Instrum.*, Vol. 27, June, 1950 A machine for rapidly processing photographic trace recordings.

(To be concluded)

Shaw Savill Liner "Southern Cross"

No. I

The Shaw Savill Line has taken delivery of the liner "Southern Cross," which is a one-class ship designed to carry a total of 1160 tourist passengers in the company's round-the-world service to Australia, New Zealand and South Africa. The ship has an overall length of 604ft, a gross tonnage of 20,200 tons, and is propelled at a service speed of 20 knots by twin sets of double reduction geared turbines. These turbines develop a total of 20,000 s.h.p. when supplied with steam at 500 lb per square inch and 800 deg. Fah., and the whole of the machinery is installed right aft to give the ship an unusual profile.

SINCE the war the Shaw Savill and Albion Company, Ltd., has been engaged, in common with many other shipping lines, in reconditioning ships and in replacing lost tonnage in order to continue the company's pre-war services to Australia and New Zealand. In evolving a building programme the replacement of cargo ships was given priority, while the policy with regard to passenger liners was to await upon events and the emergence of more clearly defined indications of the trends of passenger traffic. Conditions obtaining at most of the ports served by the company, both as regards equipment and labour, caused delays in the turn-round of ships and altered the economic pattern of ship management, especially for passenger liners. Delays due to the slow loading and unloading of cargo were not compatible with keeping a set sailing schedule and involved either delay in departure to complete loading, or sailing as advertised with cargo holds partly empty. Both of these alternatives were uneconomic and the company solved its problem by making the decision to build a passenger liner with no provision for carrying cargo, so that it could make four round voyages each year instead of three by a passenger-cargo ship.

Our illustration of the new ship on trial, when a speed of 21·35 knots was attained, shows that besides dispensing with cargo holds the owners have also departed from the conventional arrangement of machinery amidships by having the engines and boilers installed right aft. This arrangement meant that the advantages gained by the absence of cargo hatches and trunking in the layout of accommodation were augmented by the removal of engine and boiler casings which have always proved an obstacle in the design of the public rooms, service rooms and the arrangement of cabins. With the propelling machinery and electrical generators as far aft as the lines of the ship permitted, the question of trim had to be considered but, with no cargo to take into account, there remained only the disposition of fuel and water tanks and the distribution of fuel, water and ballast water in the full and burnt-out conditions, to affect the trim. This is the first British liner to adopt this arrangement, although several bulk cargo carriers have been built with machinery aft; however, it is of interest to recall that the Moore Dry Dock Company of San Francisco were building, before the war, a number of passenger liners with the main engines aft, for service in the Pacific. These ships were designed by George G. Sharp Inc., New York, and the following are the main particulars: length overall 522ft 10½in; length between perpendiculars 496ft; breadth moulded 71ft 8½in; depth moulded to upper deck 43ft 6in; speed 17 knots; cross compound, double reduction geared tur-

Dimensions and Particulars of "Southern Cross"

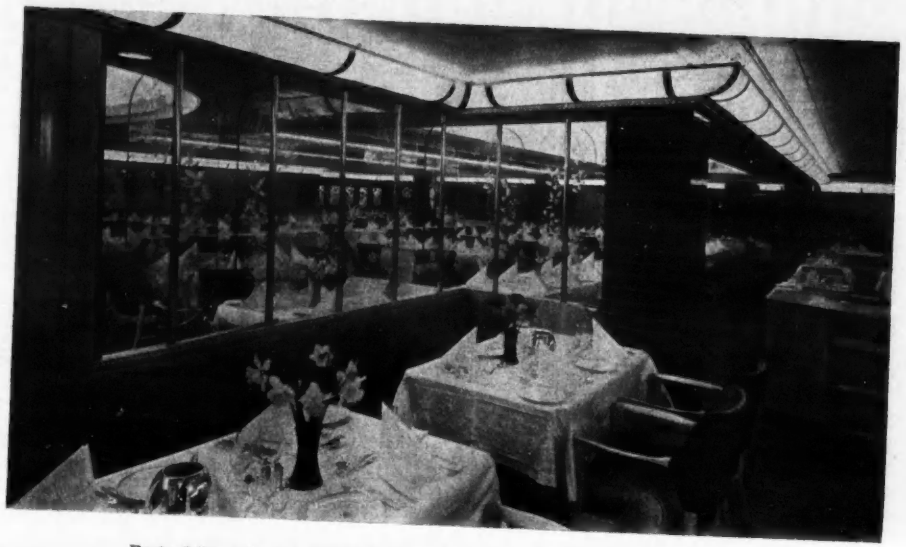
Length overall	604ft
Length between perpendiculars	560ft
Breadth moulded	78ft
Depth moulded to main deck	45ft 3in
Load draught	25ft 1in
Service speed	20 knots
Gross tonnage	20,200 tons
Displacement	20,426 tons
Accommodation	
Tourist class passengers	1160
Crew	411
Propelling Machinery	
Twin-screw, double reduction geared turbines. Normal power (at 120 propeller revolutions per minute)	20,000 s.h.p.
Astern power	12,000 s.h.p.
Steam supply	465 lb per square inch, 790 deg. Fah.
Three water-tube Yarrow boilers:	
Steam pressure	500 lb per square inch
Superheat	800 deg. Fah.
Electrical Machinery	
Six Allen generators	600kW
Driven by Mirrlees "K8" diesel engines	220V d.c.
One Harland and Wolff diesel-driven generator (emergency)	200kW

SHAW SAVILL LINER "SOUTHERN CROSS"

Forward end of lounge, showing part of decorated glass screen

Writing room looking forward to the doors leading to the lounge

The smoke room, looking aft



Part of forward restaurant showing etched glass divisions and marble pillars

bine machinery of 9000 s.h.p.; steam supplied at 465 lb per square inch and 765 deg. Fah. by two sectional header, straight tube boilers. These ships were converted to serve a variety of purposes, many becoming troop carriers.

The new liner was built and engined at the Belfast yard of Harland and Wolff, Ltd., and was named "Southern Cross" when she was launched by Her Majesty Queen Elizabeth, on August 17, 1954. It is intended that the ship will make four round-the-world voyages from Southampton each year, going either east or west about and the liner, under the command of Sir David Aitchison, K.C.V.O., who was captain of the "Gothic" during the Royal Commonwealth tour, sails on her maiden voyage on March 29th. This is a west-bound voyage, via the Panama Canal, and the ship will call at Trinidad, Curacao, Tahiti and Fiji on the way to Wellington and then visits Australian ports before returning to Southampton via Durban and Cape Town. Following her maiden voyage the ship will be engaged in a number of cruises during the months June to September, when she will resume her regular sailings.

Our illustration shows that the new ship has fine lines, a curved contour plate stem, cruiser stern, well-rounded and extensive superstructures surmounted by bridges, with radiused fronts placed a little forward of midships. Immediately aft of the bridges is a built steel mast which serves to house the exhaust from the galley, and then right aft is the large streamlined funnel with a rounded top to complete a profile which is both pleasing and distinctive. The twin-screw liner, which is powered by two sets of double reduction geared turbines, has been built under the survey of Lloyd's Register of Shipping and satisfies the requirements of the Ministry of Transport. There are a total of eight decks, all of which are used either wholly or partly for accommodating passengers and crew. Within the main hull are four complete steel decks, namely, promenade, main, saloon and "A", with "B" and lower decks extending forward and aft of the machinery spaces. The superstructure decks are named lounge and sun and above them are the lower, captain's and navigating bridges. Adequate subdivision is provided by nine water-tight bulkheads and the continuous double bottom is divided into tanks for oil fuel and fresh water. Above the tank top and forward of the machinery spaces are twenty-nine oil fuel tanks, most of which are available for water ballast. A number are arranged four in the width of the ship, others are wing tanks placed to port and starboard of the swimming pool and forward are four arranged to serve as trimming tanks. Aft of the forepeak, which carries water ballast, are fresh water trimming tanks, and fresh water is also carried in tanks in the tunnel recess and right aft on "B" deck, while the aft peak is available for either fresh water or water ballast. A passage on the centre line between the tanks gives access to the stabiliser compartment from the refrigeration and air conditioning plant and continues forward to a compartment containing sewage plant. From this space a water-tight door leads to passages on each side of the swimming pool and then a centre line pipe passage extends as far forward as the fresh water tanks. The liner is arranged as a one-class ship and a total of 1160 passengers are carried in air conditioned cabins, while additional comfort is provided by the installation of Denny-Brown hydrofin stabilisers.

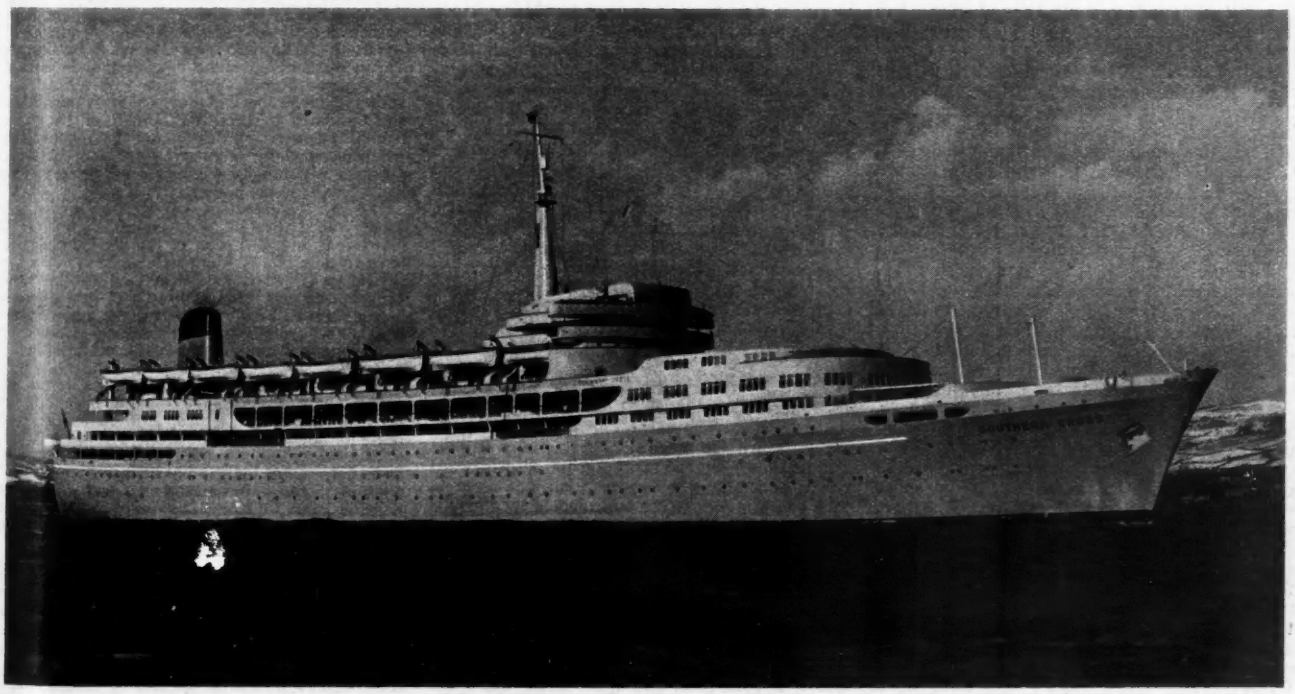
Accommodation

As already mentioned, the accommodation is arranged for tourist class passengers only, who are provided with one, two, three, four and six-berth cabins, all of which are comfortably furnished and air conditioned, and there are in all 405 rooms for 1160 passengers. Most of the one, two and three-berth cabins are located on the promenade and main decks, while the four-berth cabins are arranged on the main "A" and "B" decks, with the majority of the six-berth cabins on "B" deck. A limited number of the rooms have private bathrooms or showers attached. The divisional and passageway bulkheads within the cabin accommodation are all finished in "Formica" of which two shades have been used, blue and cream linette, on alternate decks. The machinery arrangement adopted and the absence of hatchways and hatch trunking have resulted in the introduction of a considerable number of inside cabins, and to ensure comfortable living conditions an extensive system of air conditioning has been installed throughout. One item of particular interest installed in the inside cabins is the artificial daylight system, to give the effect of sunrise, in which a special light is automatically switched on at 7 a.m. and slowly increases in intensity until daylight appears, when the light is automatically switched off.

All the public rooms, with the exception of the restaurants, are on lounge deck and right forward on this deck is the main lounge, shown in our illustration, which is a spacious room extending for the full width of the ship and having grouped windows which give passengers excellent views forward and also to starboard and port. Furnishings consist of deeply upholstered chairs and settees fitted with loose covers, and the effect of a separate centre space is created by an ellipse of slender pillars sheathed in satin-finished stainless steel. Within this area are two flood lighting bowls mounted on bases of Nigerian walnut wood in which the stars of the Southern Cross are carved from transparent plastic. Decorative glass screens to port and starboard help to break up the great expanse of the room, while a third screen on the centre line at the aft end serves to conceal the service arrangements. All the screens are etched in designs representing birds of Australia, New Zealand and South Africa, and throughout the room the effect of lightness has been maintained by the use of white ash and sycamore, and also by ornamental light fittings of leaf formation, hand made from crystal clear plastic.

At the aft end of the lounge curved screens consisting of ornamental glass, framed in white sycamore, separate the lounge from the writing room to port and the library to starboard. The writing room, of which we reproduce a photograph, is furnished in an original manner and has special lighting fittings at each table, a soft grey carpet, and is panelled in conifera wood. In the corresponding room on the other side of the ship, there are glazed bookcases of white sycamore, having shelf space for 3000 volumes, which contrast with the pale coral pink willow panelling. Both of these rooms and the lounge have double doors opening on to broad lobbies leading to the entrance hall, which is panelled in eucalyptus wood and contains a portrait of Her Majesty Queen Elizabeth II in a frame of English walnut and mounted on a curved panel of Australian walnut.

Continuing aft, a centre opening leads to the smoke room, which has banquette seating in red Vaumol hide around the sides and a formal arrangement of easy chairs, armchairs, tub armchairs and tables in natural walnut. Silver grey elm veneers, cut from piles from the old Waterloo bridge, relieved by dark walnut skirting, have been used for the flush panelling. The main decoration consists of coloured murals of the Arms of Australia, New Zealand and South Africa, placed in three corners of the room, and open grill screens in copper bronze which are placed above shaped settees and serve to mask the entrance doors at the forward and after ends of the room. Console tables at each entrance support figures carved in walnut. The circular raised ceiling, which is stepped up to a shallow central dome, is illuminated by concealed lighting



Shaw Savill Liner "Southern Cross"

forming part of the scheme prepared and fitted by The General Electric Company, Ltd.

Further aft is the multi-purpose, air-conditioned cinema lounge which measures 96ft by 44ft by 17ft in height, and in addition to serving as a lounge will be used for dancing, concerts and as a cinema. The large dance floor has raised platforms at the sides which have furniture consisting of settees and easy chairs, while the remaining furnishings will be arranged to suit the particular purpose for which the room is being used. At the aft end of the space is a large stage complete with colourful proscenium curtain, cinema screen and Gaumont British sound production equipment. An electronic organ is installed, together with a grand piano, both in cherrywood cases to match the panelling of the room, which has been carried out in English cherrywood veneer with embossed Vaumol hide panels above. Stacking chairs in green, yellow and red Varilon are provided for use when the space is serving as a cinema or concert hall ; they range in height from 14in to 18in to provide an unobstructed view of screen and stage. At the forward end is an extensive balcony which is equipped with 117 tip-up theatre seats covered in red Varilon and, to control sound effects, has its back bulkhead lined with glass wool and finished with Lanide.

A corner of the tavern, illustrating the seating arrangements

At the aft end of the lounge deck is a large room of particular interest which is named the " Tavern " and is Bohemian in character, there being face-to-face settles made of ash, with narrow tables in between and reminiscent of a Continental bier-keller. Groups of seats are separated by low screens and there is a long bar and also a small dance floor. This can be seen in our illustration, together with the seating arrangements. From the entrance at the forward end of the lounge deck is the main stairway, which is panelled in white ash, has a toughened glass balustrade enriched with metalwork of satin chrome, a framed mirror, embossed with a formalised design on each landing, and descends to the promenade deck and then to the main entrance on the main deck. Eucalyptus wood has been used for the panelling of the entrance, which has a decoration consisting of a pair of panels using Australian and New Zealand timbers. Doors having wrought metal grilles conceal the embarkation doors in the ship's side and to port of the entrance there is a shop, while to starboard is the mail office.

The main stairway descends to the forward restaurant with seating for 390 at tables, arranged for two, four, six and eight, of which groups are partially separated from one another by frameless toughened glass screens carried on metal supports and decorated with etched designs of the flowers of Australia, New Zealand, South Africa and Great Britain. These screens and other items of decoration can be seen in our illustration. The panelling is veneered with figured aspen of a golden beige colour and at the forward end of the room is a mirror embossed with water lilies, while four black highly polished marble columns form the corners of a square and also the basis of the design of the ceiling, which is panelled with sound-absorbent material. Banquette seating is arranged along the ship's side and the dining chairs have hide upholstery in four colours. There is a second restaurant aft of the galley which has 192 seats and is generally similar to the forward room. In this room the upholstery is in pale grey and yellow, and the main decoration is a formalised map of the Southern Celestial Hemisphere, carved and engraved in transparent " Perspex," while in both restaurants there is a series of relief carvings in line wood, applied to the panelling. Both rooms are fully air conditioned and entered by frameless armour plate glass doors.

From the saloon deck the main stairway descends to the lower deck, where there is a large swimming pool, which is lined with dove grey and red tiles, while the bulkheads are lined with pastel green " Perstorp " plastic. In a shallow recess at the forward end of the space is a coloured mural in glass mosaics depicting a Maori canoe on a sandy beach and surf bathers, and the wide sidewalk around the pool is equipped with tables and chairs for spectators. There is also an outdoor swimming pool, forward on the sun deck, which has tiles of blue, grey and beige and underwater lighting. The pool is raised above the level of the deck and two ladders give access to the swimmers' walk. Main stairways are arranged at the aft end of the ship to link up the accommodation and entrances on the various decks. At the entrance on the lounge deck there is a large map of the world, engraved in " Perstorp " plastic, which has the principal ports marked by small clocks which slow local time. On the deck below is an entrance hall which is panelled in eucalyptus and white beech, and where are situated the hairdressing saloons and purser's office.

There is ample deck space for walking and for sporting activities, there being a sports deck arranged above the cinema and adequate provision for the playing of deck games to port and starboard on the sun deck and also forward of the deck house, where there is a considerable area of open deck which is protected by a glazed screen having a short length of roof. On the lounge deck there is a wide promenade to port and starboard of the public rooms, while on the promenade deck there is an uninterrupted walk around the deck house. At the forward end of the house on the sun deck is a fully equipped recreation room, for the use of older children, which has bulkheads veneered in plastic and above a pale blue and light grey dado are colourful paintings of historical figures on a primrose background. For the very young children there is a playroom and enclosed play deck.

There is a suite of rooms for the captain on the captain's bridge, while on the lower bridge are the cabins for the deck officers, including a suite for the chief officer, and a smoke room. On the starboard side of the main deck are the engineers' cabins, there being a suite for the chief engineer, also a mess and a smoke room. Single, two and three cabins are arranged for the petty officers and seamen forward on the saloon deck, while the accommodation for the stewards is located to starboard aft on the saloon deck, to port amidships and forward on " A " deck and forward on " B " deck. The firemen and greasers have cabins aft on " A " deck abreast the boiler casings. Separate messes are provided for the leading stewards, stewards and crew, and there is a spacious air-conditioned recreation room for the crew on the lower deck forward. Hampton and Sons, Ltd., was responsible for the decoration and furnishing of the smoke room and the cinema lounge was the work of Maple and Co., Ltd., while the remaining public rooms and stairways have been decorated and furnished by Heaton Tabb and Co., Ltd.

(To be continued)

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

PLAIN BEARINGS (METAL)

No. 1131 : 1955. Price, Parts 1, 2, 3, 5, 4s. ; Part 4, 7s. 6d.—Part 1 : " Dimensions of Non-Ferrous Solid Bushes and Thrust Washers" ; Part 2 : " Dimensions of Wrapped Bushes and Thrust Washers" ; Part 3 : " Dimensions of Medium-Walled and Thick-Walled Bearing Half-Liners"; Part 4: " Dimensions of Thin-Walled Bearing Half-Liners and Thrust Half-Washers"; Part 5 : " Bronze Oil-Retaining Bushes and Thrust Washers."—The essential purpose of this standard is the specification of the dimensions of ranges of standard bushes, bearing half-liners and thrust washers and half-washers, which will be available without the delay and expense of making special tools, and to facilitate economic production by concentrating demand on these standard sizes. It is published in five separate parts.

Part 1, " Dimensions of Non-Ferrous Solid Bushes and Thrust Washers," specifies the dimensions and tolerances for plain and flanged bushes, both those with a machining allowance in the bore and those which are prefinished, and for thrust washers, for journals of $\frac{1}{4}$in to 5in nominal diameter. It specifies also methods of identifying the bushes and thrust washers and of marking the bushes.

Part 2, " Dimensions of Wrapped Bushes and Thrust Washers," gives the dimensions and tolerances for wrapped bushes, both those with a machining allowance in the bore and those which are prefinished; and for thrust washers, for journals of $\frac{1}{4}$in to 3in nominal diameter in inch sizes and of 10mm to 58mm nominal diameter in millimetre sizes. It specifies also methods of identifying the bushes and thrust washers and of marking the bushes.

Part 3, " Dimensions of Medium-Walled and Thick-Walled Bearing Half-Liners," specifies the dimensions and tolerances of bearing half-liners for journals of 2in to 12in nominal diameter. There are two ranges of wall thicknesses and the half-liners may be in non-ferrous metal, unlined ; or in non-ferrous metal, lined with anti-friction metal ; or in ferrous metal, lined with anti-friction metal. Methods of identifying and marking the half-liners are given.

Part 4, " Dimensions of Thin-Walled Bearing Half-Liners and Thrust Half-Washers," specifies the dimensions, tolerances and running clearances for (*a*) steel-backed, thin-walled, grooved bearing half-liners for nominal journal diameters from 1in to 6in ; (*b*) steel-backed, thin-walled, ungrooved bearing half-liners for nominal journal diameters from $\frac{1}{4}$in to 6in ; (*c*) steel-backed, thin-walled thrust half-washers for nominal journal diameters from 1in to 6in. It also gives methods of identifying the half-liners and thrust half-washers and of marking the half-liners.

Part 5, " Bronze Oil-Retaining Bushes and Thrust Washers." This part of the specification replaces B.S. 1131 : 1943, " Bronze Oil-Retaining Bearings." It deals with the materials, dimensions, tolerances, characteristics and methods of identifying plain and flanged oil-retaining bushes and thrust washers, charged with lubricating oil and having a normal oil content of from 25 to 30 per cent by volume, within the size range from $\frac{1}{16}$in to 2$\frac{1}{2}$in nominal bore.

Chemical Recovery Units for Paper and Pulp Mills

In our issues of September 3 and 10, 1954 (pages 331 and 366), we described the Tennessee Mills of Bowaters Southern Paper Corporation. The chemical recovery unit of this plant has a daily capacity of 320 tons of pulp, i.e. it can burn 950,000 lb of dry solids per day. It is designed to generate 123,200 lb of steam per hour at 850 lb per square inch and 825 deg. Fah. from feed water at 280 deg. Fah., thus saving about 130 tons of coal per day. The following article describes some aspects of the design and development of such units.

IN the manufacture of chemical pulp, the wood or other cellulose-bearing material is digested with certain solutions which combine with the lignin and resins and thus free the cellulose fibres. The chemicals used are either bisulphites of calcium, ammonium, sodium or magnesium (calcium bisulphite, 1867), or sodium hydroxide (soda process, 1880), or a mixture of sodium hydroxide and sodium sulphide (sulphate process, 1907). After the digesting, the disintegrated cellulose fibres are washed, and the excess chemicals and compounds of lignin and other organic substances are removed with the waste liquors which, in the case of the sulphate and soda processes, are termed "black liquors."

In the early soda and sulphate plants, recovery generally was confined to that of the chemicals, but the development, since about 1930, of the recovery boiler has made it possible to utilise the heat of combustion of the organic components as well, thereby saving a substantial amount of other fuel, and generating steam for power and process purposes. The chief problems encountered are those of concentrating the black liquor in an economical manner, burning a material of high moisture content, and dealing with the large quantity of low-melting slag which is deposited on the boiler tubes.

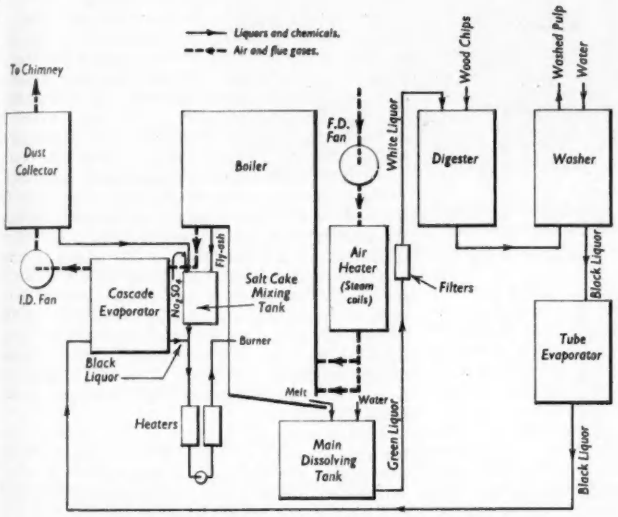


Fig. 1—Flow diagram of sulphate recovery plant

Chemical recovery from sulphite waste liquors is costly because the equipment must be made of stainless steel or other corrosion-resisting material in order to withstand the action of sulphurous acid and sulphur dioxide. In view of the cheapness of the chemicals involved, the waste liquors were usually run off into water, but regulations against stream pollution are becoming stricter and will in many places put a stop to this practice.

Recovery Plant

The earlier soda and sulphate plants thickened and burned the waste liquors in a reverberating furnace fired by an auxiliary fuel. Later, brick lined rotary furnaces were employed, in which the liquors were tumbled until they dried and charred to a black ash. These rotary furnaces were heated either by an auxiliary fuel or by the flue gases from a separate smelter furnace in which the black ash was burned. Both these kinds of plant were bulky, uneconomic with fuel and the refractories were expensive to maintain. Early rotary kilns were capable of dealing with the waste liquors from the manufacture of 40 to 50 tons of pulp per day. Later designs had a daily capacity of 75 or 80 tons.

The modern development began when spray-fired tower furnaces were introduced in the 1930's. By the end of the decade, capacities had reached 100 to 150 tons, while more recent units go up to 350 to 400 tons per day. These large units are in proportion to their output much cheaper to build than small ones, and their actual running costs are only slightly greater. Steam conditions have increased from 400 lb per square inch and 700 deg. Fah. in the mid-thirties to 1000 lb per square inch and 825 deg. Fah. at the present day. Still larger units with higher pressures and temperatures are under consideration.

Slagging conditions in a waste boiler are severe compared with those in a boiler fired by low-quality bituminous coal. The ash content of such coals is about 5 to 8 per cent, and the ash has a melting point of 2000 deg. to 2800 deg. Fah. Waste liquor fuels contain about 40 per cent ash, on a dry basis, and its melting point is of the order of 1300 deg. to 1400 deg. Fah. These characteristics of the fuel affect the design of the plant in ways which will be discussed later on.

Recovery Process

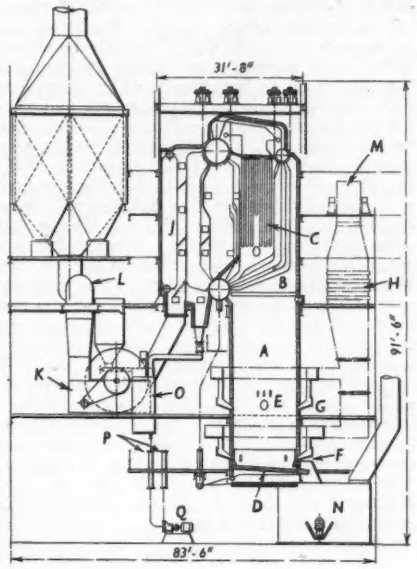
The recovery process in the case of a sulphate plant is shown diagrammatically in Fig. 1, and consists of the following principal stages :—Evaporation of water from the waste liquors and addition of make-up chemicals ; combustion in the furnace and generation of steam ; recovery of chemicals from the slag for reuse in the pulp digestors.

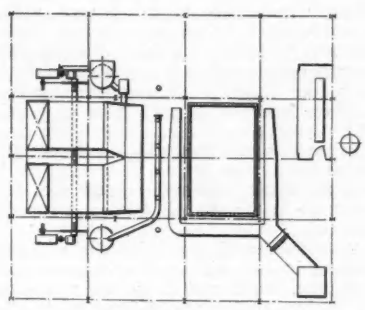
Evaporation

In order to perform the evaporation stage as economically as possible, the black liquor is obtained at the maximum permissible concentration (about 14 to 16 per cent dry solids) by washing the pulp in three-stage, counterflow washers. Standard long-tube evaporators are then used to concentrate the liquor to 50 to 55 per cent dry solids. Depending on whether quadruple or quintuple-effect evaporators are employed, from 4 lb to 4½ lb of water are removed per pound of steam. (For calcium-base sulphite waste, which forms deposits, a multiple-effect, plate evaporator was developed in Sweden some years ago by Rosenblad.)

A higher efficiency of the order of 13 lb to 14 lb of water per pound of steam is obtainable from thermal-compression evaporators. A Canadian sulphite plant, the Anglo-Canadian Pulp and Paper Company, Quebec, P.Q., is said to use an evaporator of this kind to concentrate waste liquors from 12 to 52 per cent.

The concentrated black liquor is very viscous at room temperature, but at the temperatures at which it comes from the evaporator (190 deg. to 200 deg. Fah.) its viscosity of about 250 centistokes is still low enough for efficient pumping. In order to be able to burn it in a furnace, however, further concentration to about 65 per cent dry solids is necessary, and this is done in a cascade or cyclone evaporator, in which the liquor is in direct contact with a counter-flowing stream of hot flue gases from the recovery boiler.





A—Furnace (water cooled).
B—Boiler tubes.
C—Superheater.
D—Hearth (refractory).
E—Burners.
F—Primary air inlet.
G—Secondary air inlet.
H—Air preheater.
J—Economiser.
K—Cascade evaporator.
L—Induced draught fan.
M—Forced draught fan.
N—Main dissolving tank.
O—Salt cake mixing tank.
P—Heaters.
Q—Pump.

Fig. 2—Sectional view of recovery boiler

A typical cascade evaporator unit for a 350-ton plant consists of four large horizontal paddle wheels mounted in pairs on two shafts and encased in the boiler flue so that the hot gases pass over the pairs in sequence. The wheels are fitted with a number of axially arranged tubes which dip into the black liquor to within 2ft to 3ft of the shaft, and are rotated through reduction gearing at 5 r.p.m. by a 50 h.p. motor. The liquor, which is dragged up by the wheels, presents a total area of 3400 square feet to the gas stream. Efficient use is made in this manner of low-temperature waste heat, and at the same time a large amount of fly ash is trapped and the chemicals returned to the cycle.

The concentration obtainable is strongly affected by that of the incoming liquor. A limit is set by the viscosity of the black liquor which can still be handled after make-up salt cake (sodium sulphate) has been added at the next stage.

Combustion and Recovery

After heating to 240 deg. Fah. in steam heaters in order to reduce its viscosity to about 125 centi-

stokes, the liquor is fired in the boiler by means of low-pressure spray burners. The firing can be done in one of two ways, of which the second is the more popular one. Either the spray is "painted" on to the furnace walls where it is dried and the dried scale flakes off and falls into the furnace hearth; or the spray is directed by jets rocking through 45 deg. in such a way that the fuel droplets do not touch the walls, but flash-dry while falling through the combustion zone. In doing so they bubble and expand considerably to about ¼in diameter, and in this state they burn very readily. The ash forms a cone on the hearth which melts at the top, but has a solidified base. In this way, the temperature of the refractory is much less extreme and erosion is avoided. Primary and secondary air is blown in through ports situated about 2ft and 8ft respectively above the fuel bed. By running with not more than 10 per cent excess air, conditions are obtained in which the sulphate is reduced to sulphide, as required for the process. In the soda process no reduction occurs and excess air may be increased to about 20 per cent. The molten slag is drawn off into the main dissolving tank and the solution after filtering is recirculated to the digesters.

Boiler Design

The boiler unit is shown in Fig. 2. A completely water-cooled furnace is used, with only a thin layer of chrome refractory on the hearth in order to keep up efficient cooling. Special steps have to be taken in the design of the boiler to reduce slagging. The superheater is built up from banks of tangent tubes on which the slag cannot obtain a firm grip. The common practice is to use retractable steam soot blowers in the first and second air passages of the boiler and automatic sequential air-puff soot blowers are used in the second, third and superheater sections.

A forced draught fan is installed which passes the combustion air through a steam-operated preheater. Steam rather than flue gas is used for air preheating because this system is effective also at starting up when preheating is most needed. Moreover, the large amount of ash in the flue gases quickly clogs the air passes in a heat exchanger. Because of the liability to clogging, the induced draught fan must be amply dimensioned (30 per cent rating factor, 100 per cent static pressure factor), and the fan blades must be short in order to avoid unbalance due to slag accretions. Hydraulic couplings between the fans and their motors are used to control the air flow by varying the speed of the fan.

Boiler Controls

Indicating meters are used to measure the pressure at the air heater inlet and in the primary and secondary air ducts. Draught gauges are installed in the furnace and in the first, second and third boiler passage, economiser outlet and cascade outlet. In conjunction with those instruments, a multi-pointer temperature recorder registers the temperature of the gases in each of the above locations of the furnace. The readings serve as a guide for operating and cleaning the boiler; no elaborate combustion controls are necessary since the boiler is operated under base load conditions.

Fuel Analysis

Both for the design of the plant and its efficient operation the composition of the black liquor in terms of dry solids, as well as the ultimate analysis of the dry fuel, must be accurately known. A typical analysis is shown in Table I. The calorific value depends on the kind of wood used, and higher values of the order of 7500 B.Th.U. per pound have been recorded elsewhere.

Table I—*Ultimate Analysis of Dry Solids from Sulphate Waste Liquors; H.C.V.=6900 B.Th.U. per Pound Dry Solids*

	Per cent
Organic :	
Carbon	41·7
Hydrogen	4·0
Sulphur	1·5
Sodium	11·55
Oxygen and nitrogen (by difference)	27·0
Inorganic :	
Sodium hydroxide	1·7
Sodium sulphide	1·75
Sodium sulphate	2·9
Sodium carbonate	7·9
	100·00

Sources and Quantities of Fuel

The amounts of fuel which are or could be utilised in recovery processes are substantial. Kennedy estimates that of the 1952 production of pulp in the U.S.A. of some 12,000,000 tons. the sulphate process accounted for 74·2 per cent, the sulphite process for 22·5 per cent, and the soda process for 3·3 per cent. On a basis of 340 working days per year, 3000 lb of dry solids per ton of pulp, and 3·3 lb of high-pressure steam per pound of dry solids, this pulp production each day gives rise to 41,250 tons of dry solids, equivalent to 137,500 tons of high-pressure steam. If one assumes that the calorific value of the dry solids is 50 per cent that of coal and the generating efficiency of a recovery boiler ⅔ of a coal-fired boiler, the amount of coal which is or could be replaced by burning dry solids is 13,750 tons per day in the United States alone, with further large quantities burned or available in Canada and Scandinavia.

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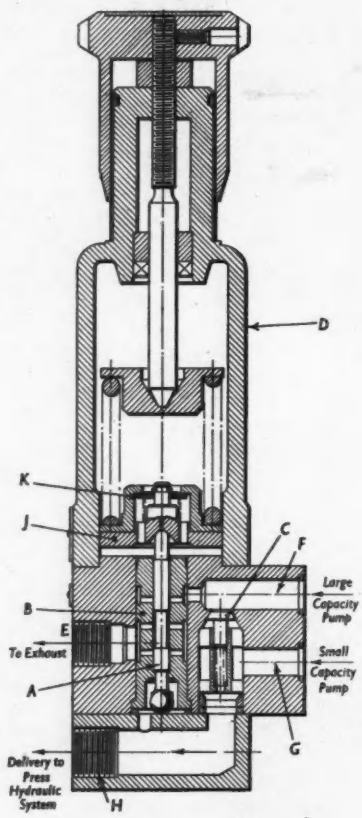
Hydraulic Equipment for Industrial Diamond Manufacturing Plant

IT was announced recently that a firm in the United States had succeeded in manufacturing industrial diamonds by a process in which carbonaceous material had been subjected to a temperature of over 5000 deg. Fah. and a pressure of over 1,000,000 lb per square inch. We are informed by Towler Brothers (Patents), Ltd., of Rodley, near Leeds, that the hydraulic pressure required in the process was obtained and controlled by the firm's pumps and control valves fitted to a press made by the Birdsboro Steel Foundry and Machine Company.



Pressure relief and unloading valve

The pumps used were of the standard "Electraulic" axial plunger design, working at 5000 lb per square inch, the pressure of the hydraulic fluid being intensified by means of a multiple-ram system. In order to get the desired result, it was essential to use an exceedingly accurate control of pressure and a special variable-pressure relief and unloading valve was developed. In tests it was proved that this valve would maintain a pumped pressure of 5000 lb per square inch for several days with a variation of only ±0·1 per cent of the maximum pressure. The valve is made adjustable so that it can be set to maintain indefinitely almost any given pressure within its range without material variation.

The design of this variable-pressure relief and unloading valve can be seen in the drawing reproduced on this page. It is used in a system where there are two sources of high-pressure fluid supply, and its function is to unload one of the sources of high-pressure supply and by-pass it to exhaust at zero pressure just prior to the set maximum pressure being reached. The other source of supply is by-passed to exhaust, also through the valve, when the maximum set pressure has been reached. An example of this is when this valve is used with a pump with two separate deliveries, one being smaller than the other. The larger of the two deliveries is by-passed to exhaust at zero pressure while the smaller delivery is maintaining pressure in the system. The oil not required by the system for maintaining pressure is by-passed through the valve at the preset pressure.

The drawing we reproduce of the valve shows the position of the component parts when delivering the maximum volume of fluid to the hydraulic system of the press. The unloading body at the lower end of the assembly houses the spindle *A*, a bush *B*, a check valve *C*, and a calibrated spring assembly in the casing *D*. A connection *E* in the body leads to the exhaust tank. Two connections are fitted in the extension of the valve body, one above and one below the check valve *C*, the upper connection *F* being coupled to the large capacity high-pressure supply from the pump and the lower connection *G* to the small capacity high-pressure supply from the pump.

The combined delivery from both high-pressure supplies is passed through the valve by way of the connection *H* in the bottom chamber of the body. The pressure built up in the system acts on the bottom of the valve spindle, which is held down by the load imparted by the spring. When the pressure in the hydraulic delivery system overcomes the load applied by the spring the spindle is lifted. A reduced neck on the spindle then connects the two series of radial holes in the upper part of the bush B and permits the fluid from the large capacity pump to pass straight through into the exhaust. Whilst this supply is being passed to exhaust the check valve comes into effect to hold the pressure in the system and, at the same time, the smaller capacity pump continues to deliver fluid.

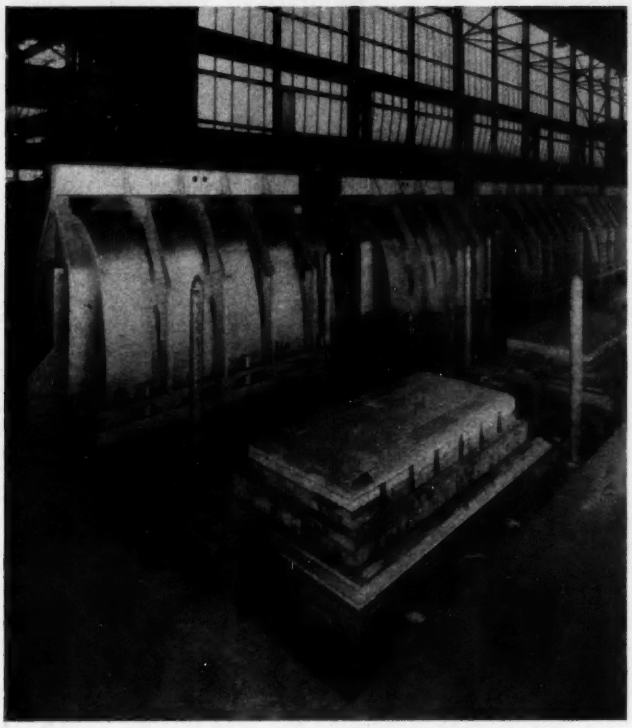
When this continued delivery gives a small further pressure rise in the system the spindle is lifted still further until the reduced section at the lower end of the spindle registers with the bottom set of radial holes in the bush, and allows the fluid in the delivery system to escape to exhaust. Thus, any surplus oil being delivered into the hydraulic system and not required for maintaining it at the required pressure, escapes at that pressure.

A fall in pressure in the hydraulic system supplied through the valve causes the spindle to fall under its spring loading. This first cuts the connection between the system and the exhaust, and the small capacity pump output is delivered once again into the system. Any slight further drop in pressure is followed by a further lowering of the spindle to cut off the connection between

the large capacity pump supply and the exhaust. Then the supply from both pumps is delivered into the hydraulic system to restore it to the preset pressure controlled by the spring load on the valve spindle.

Damping to prevent hunting and vibration is provided by the spring pad assembly. The periphery of the spring pad *J* is radiused to accommodate any slight tilting of the pad to deformation of the spring. Clearance between the pad and the spring casing allows the transfer of oil from below to above the pad when the spindle is falling. This clearance is such that the falling speed is limited sufficiently to prevent overrun and hunting. The spindle can rise rapidly as oil can be drawn freely into the underside of the spring pad through the opening of the flap valve formed by the rubber washer *K*. This rubber washer is backed by a steel washer and is lightly held by spring pressure. Passages are drilled in the spring] casing and the valve body to drain fluid back into the exhaust connection.

A knob at the top of the assembly can be turned to adjust the load on the spindle spring in accordance with the pressure it is required to maintain in the hydraulic delivery system. A distance piece fitted over the adjusting screw limits the movement of the knob to prevent a setting which would cause an excessive pressure in the system. An "O" ring is fitted on the neck of the valve body over which the setting knob sleeve passes, and this ring provides a sufficient frictional hold on the sleeve to prevent the valve setting being altered due to vibration. For the actual installation the control knobs were replaced by hand wheels.



Lift-off bell furnaces for the heat-treatment of silicon steel sheet, at temperatures up to about 1100 deg. Cent. Two hearths are supplied with each furnace, which is rated at 180kW

Electric Heat-Treatment Bell Furnaces

THE photograph we reproduce on this page shows one end of a line of six lift-off bell furnaces installed at the works of Joseph Sankey and Sons, Ltd., Wolverhampton, by Birlec, Ltd., Erdington, Birmingham, for the heat-treatment of silicon steel sheet—a process which involves temperatures of up to about 1100 deg. Cent.

The furnace bodies are parabolic in shape, a section which provides the maximum constructional strength at heat and ensures the greatest possible degree of temperature uniformity throughout the charge. Heating elements of nickel-chromium strip arranged in two zones are secured to the furnace brickwork by the maker's removable hookpin method, which has a particular advantage in equipment operating at high temperatures where a comparatively short life may be expected. To renew the elements, the pins are simply withdrawn and they can be replaced without disturbance of the brickwork.

Each furnace is supplied with two hearths, so that the greatest output can be obtained from the heating potential of the equipment. After a charge has reached a sufficiently low temperature in its cooling cycle to prevent oxidation on exposure to air, the furnace bell is transferred to the companion hearth, where it heats up a fresh charge. The first charge is then covered with a sheet metal hood, to which a supply of protective atmosphere is maintained. These hoods are of rectangular construction to conform to the stacking of the metal sheet on the hearths.

The hearths are built up of a plinth of refractory and insulating brickwork on a structural steelwork base. The flanges of each bell engage in the hearth in a continuous trough filled with "Cerrobend"—a low temperature sealing metal—to ensure that no atmosphere losses occur at this point, and electric heaters are built into the sealing channel to melt the metal. Each furnace is located on its hearth by two guide posts, set at diagonal corners, and each hearth is provided with a plug box to take the furnace bell socket for the electrical connections.

The non-oxidising furnace atmosphere is obtained from an I.C.I. ammonia gas generator comprising a standard cracker, with catalyst, and a regenerative ammonia burner. To obtain the low dewpoints required, the atmosphere is passed through standard Birlec "Lectrodryers," one to each furnace. These dryers work on the principle of adsorption by activated alumina, a granular substance with the ability of taking up moisture from gases passed through it, and also of releasing it when heated, without deterioration of its drying properties. In this installation, as is usual, the dryers are of the "dual adsorber" design so that, whilst one bed of alumina is drying the gas, the other is being reactivated by heat. Continual drying is thus obtained, the duties of the beds being changed over at about eight-hour intervals.

Each of the six furnaces is rated at 180kW, and for power supply purposes they are divided into two groups of three. The power supply to each group of furnaces is fed to a 550kVA transformer, made by the Electric Construction Company Ltd., providing current to the furnaces at 210V, two phase. The switchgear for the installation was supplied by Contactor Switchgear, Ltd., and is of double-pole design with overload protection and time lags for each phase.

Each furnace zone is provided with a Kent combined indicating control and programme regulator, calibrated 0–1200 deg. Cent. The control instruments for each of the furnace groups are mounted on a common control panel which is arranged in line with the electrical gear.

Vanadium Poisoning from Gas Turbines

THE increasing trend towards the use of heavy residual oils for boilers, diesel engines and gas turbines, may give rise to a danger to public health on account of the presence of vanadium compounds, in particular the pentoxide in the products of combustion. Organically combined vanadium is present to a greater or lesser extent in all crude oils, and during fractional distillation becomes concentrated in the heavy residuals. The vanadium pentoxide which is formed when such oils are burned is a powerful irritant of the respiratory system, with a delayed effect. With water it forms an acid solution which irritates the skin and eyes. Poisoning due to handling of industrial vanadium compounds, as reported in the medical literature, takes the form of chronic bronchitis and emphysema.

Acute effects caused by the vanadium pentoxide-bearing soot of oil-fired boilers have also been observed. In a recent account* details are given of an accident to men working on the heat exchanger of a gas turbine which had been run experimentally on residual fuel oil. The work (which was carried out wet) consisted in removing tubes with pneumatic chisels from the heat exchanger.

Vanadium pentoxide has a corrosive effect on steel, and the tests had been run with additives such as magnesium acetate and ethyl silicate which have the object of converting the pentoxide into an inactive vanadate, or into a silicate which passes through the turbine as a fine dust. The deposits in the heat exchanger consisted of layers from the different runs, and contained 11 to 20 per cent vanadium, presumably mainly vanadates and vanadium silicates. In spite of the less active nature of the dust, the people affected showed severe symptoms the onset of which varied from one to fourteen days after exposure. The effects lasted from one to two weeks. Nose bleeding was the first signs in five of the men, and acute cough, tightness or pain in the chest, and breathlessness followed, as well as alimentary and skin troubles. Protection in this particular case was achieved by the use of waterproof protective clothing and boots and by wearing externally supplied breathing apparatus. The author of the report suggests that devices may be used to carry out cleaning automatically instead of by hand, thus making it unnecessary to do similar work on future installations. Nothing, he states, is known as yet about the concentrations of vanadium dust produced by industrial plant running on various grades of oil, nor is the maximum permissible concentration known, but it is possible that with widespread use of residual fuel oils, the effects of vanadium may come to rank on a level with those of sulphur dioxide and other harmful products of combustion.

Technical Report

Chlorine: Methods for the Detection of Toxic Gases in Industry. Leaflet No. 10. Revised edition, 1955. Department of Scientific and Industrial Research. H.M.S.O. Price 9d.—The original leaflet was published in 1939 and in the new edition the sections on occurrence, poisonous effects and first aid have been rewritten but the method of detection is unaltered. Chlorine is widely used in industry and there is always a risk of exposure during both its manufacture and use. It is an acute irritant to the mucous membranes of the eye, nose, throat and lungs, and even in very low concentrations it may be dangerous on prolonged exposure. As little as ten parts per million in the atmosphere produce severe coughing and eye irritation within a period of one minute and a concentration of over ten parts per million can have serious effects which may develop at any time within two days after exposure. Therefore, a practical test for the presence of the gas must be able to detect at least one part per million without requiring a large sample. The leaflet describes a simple industrial test, based on colour change, and gives complete instructions for carrying it out and also a diagram of the apparatus.

* R. C. Browne, "Vanadium Poisoning from Gas Turbines," *Brit. J. Indus. Med.*, 1955, 12, 57.

THE ENGINEER

Vol. 199 MARCH 18, 1955 No. 5173

LEADING ARTICLES—
Scientific and Industrial Research 382
Automatic Factories 382

ARTICLES—
"Automatic Factory" 369
Bronze and Brass Founding 365
Centreless Grinding Machine. (Illus.) 390
Chemical Recovery Units for Paper and Pulp Mills. (Illus.) 379
D.S.I.R. Report for 1953–54 365
Duplex Pipe Flange Facing Machine. (Illus.)... 390
Electric Heat-Treatment Bell Furnaces. (Illus.) 381
Electrical Engineers' Exhibition. No. II. (Illus.) 387
Hydraulic Equipment for Industrial Diamond Manufacturing Plant. (Illus.) 380
Improved Traffic Controls at the Monument ... 365
Industrial Participation in the Development of Atomic Power 390
Institute of Marine Engineers' Annual Dinner... 365
Laboratory Production of Pure Titanium Powder. (Illus.) 389
Liverpool Steam Ship Owners' Association Annual Report 365
Method of Heating Control. No. I. (Illus.) ... 373
Opening of V.H.F. Service by B.B.C. 369
Plastic Strain and Stress Relations at High Temperatures. No. I. (Illus.) 366
Science Teachers and Industry 365
Shaw Savill Liner "Southern Cross." No. I. (Illus.) 375
Small Laboratory Radiant Heater. (Illus.) ... 389
Some Commonwealth and Foreign Civil Engineering Schemes. No. II. (Illus.) ... 370
Two Canadian Prestressed Concrete Bridges. (Illus.) 391
Vanadium Poisoning from Gas Turbines... ... 381

AMERICAN SECTION—
Research in High-Energy X-Rays. (Illus.) ... 394

LETTERS TO THE EDITOR—
Reports from the Footplate... 383
Conjugated Valve Gears on "V2" Locomotives 383

LITERATURE 384
Books Received 383
Short Notices 386

NEWS AND NOTES—
African Engineering News 393
British Patent Specifications. (Illus.) 399
British Standards Institution 378
Contracts 398
Forthcoming Engagements... 400
Indian Engineering News. (Illus.) 392
Industrial and Labour Notes 397
Launches and Trial Trips 400
Personal and Business... 398
Technical Report 381

SCIENTIFIC AND INDUSTRIAL RESEARCH

Almost always the annual report upon the work of the Department of Scientific and Industrial Research provides food for thought. The example just published—that for the year 1953–54—is no exception. Up till last year both the bodies that contribute to the report—the Committee of the Privy Council for Scientific and Industrial Research and the Advisory Council—were firmly critical of governmental policy which not only held down expenditure upon research, but made that expenditure subject to annual grants. Since then, however, more satisfactory arrangements have been made. In December, 1953, little more than a year ago, an agreement was reached which went very far to meet the complaint of the Committee and of the Council that it was not only difficult, but in several respects uneconomic to organise the work of the Department when the annual income was liable to fluctuate unpredictably in accordance with a Chancellor's estimate of the financial state of the country. The understanding reached in 1953 provided for a gradual increase in the Department's activities over a five-year period, for an increase of about £900,000 in the annual net Vote of the Department over that period and for a building programme costing about £6,000,000. The financial arrangement is such that expenditure over the five-year period is the criterion, not expenditure in any individual year, thus permitting the work of the Department to be planned well in advance and permitting also much more flexibility than hitherto in the rate of expenditure in any year. It is true, as the Minister made clear in announcing the arrangement before the House of Commons, that its provisions are still subject to the necessary funds being voted annually by Parliament. But at least the work of the Department has been freed from disturbance over the quinquennium from anything less severe than "a marked change in the economic situation or . . . major changes in costs." The report that lies before us records the satisfaction of the Council with the arrangement. For though it feels, to quote its own words, that "there is no Establishment in the Department to which considerably greater resources could not, with profit, be assigned," it recognises also that there are only a limited number of scientists available and that there must be a fair division of that number between the Department, industry, the universities, schools, &c.

There is one disturbing note in the report. The Department grants maintenance allowances to enable graduates, deemed particularly suitable to become research workers, to undertake post-graduate studies. But of all the graduates in receipt of allowances and, broadly, too, of the larger number applying for them, only 10 per cent are interested in engineering as against 40 per cent in chemistry, 30 per cent in physics, 10 per cent in biology, and 10 per cent in other sciences. Thus there is reflected in the Department's affairs the fact, apparent in universities, that youngsters in choosing careers tend to prefer pure science to technology. The cause is possibly to be found in the schools, possibly in the prestige of pure science in parental eyes. But fortunately, in this instance, there is reason to believe that there is an additional factor. The Council shares the view of most engineers that a young graduate needs to acquire practical training and experience in engineering before returning to research work. The consequence is that before returning to post-graduate work he has become capable of earning within industry an income substantially larger than the maintenance grants the Department offers. The cure, therefore, may lie in offering higher grants to engineering than to other graduates and that is what the Department proposes to do. The report also records a notable extension of the work of the Department into certain fields in which it has only recently become interested. In the spring of 1954, the first report of a joint committee between the D.S.I.R. and the Medical Research Council on "Human Relations in Industry" was published, and the Advisory Council was much impressed. "Looking ahead," it is remarked, "we may well be encouraged by the history of the development of the natural sciences to expect that out of numerous discrete investigations there will some day emerge a useful body of knowledge, and some general principles, which together will enable industrial progress and development, not merely to satisfy economic needs, but also to make a full contribution to social welfare and human happiness." A major section of the programme being undertaken relates to problems of management and of human relations arising out of technological changes, a matter of no little importance in these days when there is so much talk about what the Americans so inelegantly term "automation."

It is one thing to carry out researches. It often proves quite another to get the results applied. There is, normally, little difficulty about publication. Journals, such as this one, are eager to print the material and Institutions exist in plenty before which papers can be presented. But publication does not ensure application, as, very soon after it was set up, the Production Engineering Research Association, in particular, realised. That body almost from its beginnings applied a good deal of its energies to taking its discoveries into industrial works and to keeping very active contact with producing firms likely to be able to profit from its work. Publication, in fact, is not enough. Demonstration also is needed. Now the Intelligence and Information Division of the Department is beginning to work on similar lines. It is expected that, working through the appropriate research or trade associations, it will help by providing "demonstration" projects to pioneer new fields of industrial application and indicate the practical value of particular industrial engineering techniques, and carry out surveys and studies to evaluate new industrial engineering techniques and explore their field of application. It is a development very much to be welcomed.

AUTOMATIC FACTORIES

Perhaps because a Conference of the Institution of Production Engineers in June is going to take the subject as its theme there is much talk at present about "automatic factories." It might almost be supposed, therefore, that an entirely new factor was entering into production methods. In fact, of course, automatic methods of manufacture have been used for many years. For long, for example, the parts of electric lamp bulbs have been assembled on automatic machines with a large number of stations at each of which a single operation is performed so that the only attention needed is that of a skilled attendant who can put right anything that needs adjustment. It may be claimed, of course, that machines of that character are analogous to the ordinary "automatic" found in almost every machine shop than to the tools and sets of interlinked tools that would be found in an automatic factory. But the fundamental idea of an automatic factory is that,

without human intervention, the workpiece shall be moved from station to station for the performance of machining or assembly operations, and that the operations at each station shall be automatically performed. There are certainly examples to be found in a number of industries of series of operations so performed. Many of the processes occurring in chemical works are automatically controlled ; some of the operations performed in steelworks approximate to " automation " in, for example, the operation of a blast-furnace or the working of a continuous mill, and in some food processing operations there is a close approximation to full automation. What is new in the idea of the automatic factory is not the suggestion that a whole series of operations shall be automatically performed, but that all or nearly the whole of the operations in the factory shall be so done.

That there would be great benefits for this country, where the labour force is unlikely much to expand in the future, through the wider adoption of " automation " can hardly be doubted. Mr. Kelley, chairman of the Conference Programme Sub-Committee of the Institution of Production Engineers, stresses these benefits in an article on page 369 of this issue. For "automation" can result in startling increases in output per man-hour. A recent issue of the PERA *Bulletin* quotes, for example, a reduction of direct labour in coil spring manufacture from 248 to thirty-eight men for the same output, and the replacement of a line of eighteen standard machines on which thirteen operators produced 750 motor-car gearboxes per week by an automatic transfer plant about 60ft in length by the use of which four men now produce 1600 boxes in the same time. Of course, there are disadvantages as well as benefits. An automatic transfer plant of the kind just mentioned must necessarily prove expensive and cannot therefore be installed unless high outputs can be justified. But even so the cost on the basis of the output attained may be no higher than that of the line of conventional machines replaced. A very high standard of reliability needs, of course, to be built into the plant ; for every stoppage must prove costly ; tools must be long-lasting and easily and rapidly replaceable ; it may sometimes be necessary so to devise controls that the machine automatically stops whenever a tool needs changing. But the term " automation " does not, it appears, cover only mass production machines of the kind so far discussed. It is equally applicable to the automatic operation through electronic control and magnetic or punched tapes of ordinary conventional tools such as lathes and milling machines. There the future possibilities seem as exciting for small-scale production as the actuality is now for mass production. For since the controlling means can be very simply changed the system, it appears, could be used with advantage even for very short runs, and there is a possibility that even one-off jobs may eventually be manufactured at a cost in man-hours not greatly exceeding that of mass production.

Economically, whether or not fully automatic factories ever come into being, will be ruled by comparative costs of production and assessments of the size of the market for the product. But economics may not prove to be the sole ruling factor. For wherever productivity is raised so, too, are fears of unemployment raised amongst workers. In rapidly expanding industries these fears can usually be allayed. But not all industries can expect to enjoy such expansion, and in many to-day restrictive practices are undoubtedly delaying the introduction of improved machinery. Yet there is a quality about automatic means of production that ought to appeal to trades unions as much as the high productivity appeals to employers. The skilled man enjoys using his skill in the factory as much (and sometimes more) than he enjoys his leisure outside its doors. By contrast, conventional mass production methods which call upon numbers of human beings to perform day in and day out a repetition of certain simple motions, reduce human beings in the factory to automata. The system is one only justifiable because it enables high wages to be paid. But it is unquestionably wasteful of human intelligence, and it creates a sharp break—surely very undesirable upon human grounds—between unenjoyable " work " in the factory and unenjoyable leisure outside it. Where the automatic factory scores lies in the fact that a large proportion of the unintelligent human activity is replaced by automatic machinery. Proportionately to the labour force employed a greater number of skilled and semi-skilled maintenance men and attendants are required, and more brains and intelligence have to be utilised in the design and manufacture of the machines. On grounds of human dignity if upon no other, an automatic factory is much to be preferred to a mass-production factory. It should, too, prove easier to establish satisfactory relationships between managements and men within it.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

REPORTS FROM THE FOOTPLATE

SIR,—Oh, Dr. Tuplin, how could you ! I thought locomotive crews loved these little chats after a run. Now I shall never dare to speak to these godlike beings again.

Would you rob us of all our romance ? We, who ride the "Woolgatherers' Special " with stop-watch and notebook ? Admittedly, we do not even handle these quite objectively. For thirty years the railway speed record was held to be 102 m.p.h., until some unkind realist looked into the figures. But really, to quote a driver who does not carry any sort of watch and barely looks at station clocks !

Pardon me, Mr. Editor, Sir, that emotion has made me address your distinguished contributor directly over your head.

Now, seriously, Dr. Tuplin's article is the real thing. It has the flavour and the tang and the zest of life. Stop-watches are useful, but we have had too much of them, and too little of this, which is their necessary complement. I wonder if locomotive designers have also had too little direct reporting back from the track. To judge from their productions, with their frequent amazing indifference to practical considerations, it is all too probable. Not that it matters much now, for their craft is passing into history. The last pencil is being laid down, and the next one sharpened will draw something altogether different, wherein water is cooled, not heated, and steam must not be generated, wherein inspection of the fire for holes and dancing is a matter, not for the crew, but for a highly equipped laboratory.

It is to be hoped that Dr. Tuplin will give us some more, or inspire others to do so. One would almost advocate a general appeal to the Associated Society of Locomotive Engineers and Firemen, for their members to come to Dr. Tuplin and " tell the tale," a thing which most people are not averse to doing. There are many routes, locomotives, conditions and periods which should be covered. To name one, how fascinating it would be to hear from some driver from the " heroic " period of the Great Central, when its hand was against every rival, and always at some disadvantage, and when it never refused, and often initiated, a challenge. What was the spirit like among its locomotive men then ? It should not be too late to find out, if they all live as long as their chairman, Sir Sam Fay, and Dr. Tuplin might find some of them in Sheffield.

A. M. CONYBEARE

Bletchingley, Surrey,
March 14th.

CONJUGATED VALVE GEARS ON " V2 " LOCOMOTIVES

SIR,—It is surprising to read that Mr. Holcroft and Mr. Nock accept the implication in the B.R. official test bulletin on the " V2 " locomotives that because the locomotive under test had been overhauled shortly before being sent to Swindon the conjugated valve gear was in good condition and set in the way the designer intended.

All engineers directly concerned with production and maintenance know only too well that, these days, even in the best ordered concerns, mistakes do occur and equipment is turned out which is below standard. Surely this is what had happened to the " V2 " locomotive under test, the centre valve had accidentally been set a considerable distance away from its intended position. Is not this confirmed by the test results ? Regular travellers by the East Coast route know that the standard of maintenance has improved immensely since the early post-war years, and Gresley three-cylinder locomotives now do not normally produce the violently uneven drawbar pull and oscillations recorded in the tests.

It seems, as Mr. Holcroft says, that Swindon kept to their " brief " very closely and accepted the valve gear without question. If my surmises are correct, surely, now is the time for British Railways to make a frank admission about the conjugated valve gear on the test locomotive before the experts, professional and amateur alike, reach " final " conclusions on it. The farce of Piltdown man must not enter engineering circles ! If British Railways can be persuaded to make a statement, it would be admired for its frankness and courage, while the Eastern Region engineers could be assured of understanding appreciation of their difficulties from those who have had similar experiences in other fields.

F. P. FROST

Middlesbrough,
March 12th.

Books Received

Engineering in Agriculture. By P. H. Southwell. London : Temple Press, Ltd., Bowling Green Lane, E.C.1. Price 30s.

Theory of Structures. Fourth edition. By H. W. Coultas. London : Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 25s.

Strength and Resistance of Metals. By J. M. Lessells. London : Chapman and Hall, Ltd., 37, Essex Street, Strand, W.C.2. Price 80s.

Introduction to Atomic and Nuclear Physics. Third edition. By Henry Semat. London : Chapman and Hall, Ltd., 37, Essex Street, Strand, W.C.2. Price 50s.

Literature

Industrial Management. By MEMBERS OF THE STAFF OF THE UNITED STEEL COMPANIES, LTD., with a foreword by PROFESSOR J. F. BAKER, O.B.E., M.A. Sheffield: The United Steel Companies, Ltd., 17, Westbourne Road, Sheffield, 10.

THIS book gives the substance of a series of lectures delivered by different officials of the United Steel Companies to undergraduates of Cambridge University, and is primarily intended for private circulation to those specially interested in the subject. A large number of young men feel drawn to management as a career with only a very hazy conception of what is involved, and to them a book of this nature must prove valuable in furnishing a comprehensive outline of the subject. It should, however, be pointed out that in giving this insight into industrial management it is the management of this one big business that is described. At the same time the general principles are applicable to most engineering firms, and a manager or other executive, as well as the student, will find much food for profitable study. In his foreword Professor Baker, speaking of these lectures, expresses the opinion that "there is no doubt that they will receive as enthusiastic a reception from the wider audience to which they can now be introduced as they did from the undergraduates," and with this sentiment we are in agreement.

The different branches of an important subject are dealt with in the following order: the role of the directing authority in a large company; production management in an integrated iron and steel works; administrative controls in management; the duties and problems of the chief engineer in a large works manufacturing special steels; organisation and application of scientific research in industry; planned development and planning a large steel works; and, finally, staffing a steel works—problems of training from the apprentice to the manager; such is the general scope of the work before us.

In all management problems it is ever essential to bear in mind that one individual cannot properly be responsible for more than half-a-dozen different activities, and Mr. Steel, the managing director, rightly points out the importance of devolved authority, indeed, every official should know, not only to whom but also for whom he is responsible. For this reason the managing director is spoken of as the "manager of managers." We are not convinced that the doubts expressed as to whether a first-class scientific man would welcome an administrative post are justified. Too often he is regarded as a "back room boy" and not given the offer of an administrative position. This state of affairs was very noticeable in the British Civil Service. In dealing with good management Lieut.-Commander Wills states that "the real problem of management is the organisation of individuals so that their work is useful as opposed to being wasteful," but we are tempted to ask how he would ensure this in a factory run on functional lines. Admittedly his organisation chart, and the "family tree" in the following chapter on administrative controls, help, but there is no doubt that "no man can serve two masters," a state which may still arise. The duties of the chief engineer vary considerably according to the nature of a firm but generally speaking they are mainly confined to problems of maintenance and services, but in the large concern described they are definitely wider for we find this official engaged on different schemes, such as preparing one for the generation of electricity from waste heat using a closed cycle gas turbine.

While, undoubtedly, the young man keen on management will not concern himself with thoughts of research, indeed, many a seasoned manager looks askance at it, it is well to have the subject included and to stress its importance in a progressive undertaking, and as evidence of the importance attached to the research worker and his zeal his motto is arresting: "Difficult jobs are done quickly, the impossible takes slightly longer." Among the very real difficulties encountered in planned development is that of broken promises for components, &c., which have to be purchased, and without which planned dates cannot be realised. Mr. Paterson, in speaking to students about this bugbear, said: "In your future careers, gentlemen, I do beseech you to regard completion dates as you would your own personal promises, they are tremendously important." We cordially agree and would counsel all managers to give more consideration to the subject. The value of following up promises is pointed out, and the necessity for tact is stressed as well as the desirability of offering a helping hand rather than blaming a contractor. Such thoughts as these lead us to the final study, that of staffing the works, and it is very interesting to learn that this big organisation has to arrange for the annual recruitment of forty "good men and true" for appointment to senior posts. These are divided into three categories: (1) senior executives; (2) intermediate management, and (3) junior management. These are further broken down into: (*a*) general; (*b*) engineering, and (*c*) scientific, always allowing for a degree of flexibility. Certain qualities are expected from everyone, including personality, ability to reason logically and a capacity for leadership. It is suggested that the aim of each member of the upper staff should be "to keep a population of 32,000 people happily at work." If this desideratum is attained many of the problems of management would be automatically solved.

In the concluding paragraph of an interesting and instructive book we read: "because the times are challenging, they require of all of us in response, the best of our thought, of our courage, of our persistence, and I would hasten to add to this—a robust and lively sense of humour." Having read this book, it is felt that other universities and technical colleges who train engineering students might with advantage follow the lead set by Cambridge, by arranging for a series of lectures to third year undergraduates by industrial experts.

Diesel Engine Operation and Maintenance. By PROFESSOR V. L. MALEEV. London: McGraw-Hill Publishing Company, Ltd., 95, Farringdon Street, E.C.4. Price 61s.

IN books about any kind of engines it is always necessary that the writer be practical. This does not mean that he shall be less generous in diffusing information on the strictly scientific aspects; but, above all, the writer of books about engines must have that background of practice without which he cannot win the true interest of the reader. If this interest be not generated, the writer of the book will not rise to the level of a teacher. Professor Maleev has the advantage of long experience, not only in the teaching of engineering, but in the construction and operation of diesel engines. He thus possesses exceptional qualifications for writing a book on *Diesel Engine Operation and Maintenance.*

The appearance of such a book is, at the present time, most opportune, since there can be no doubt about the increasingly serious need for men skilled in the care and maintenance of oil engines. "Each new diesel engine sold or installed represents (writes Professor Maleev) an avenue whereby skilled men, versed in the operation and repair of diesel engines, are able to find profitable and continuous employment." It is very true, though engine users will agree that if the employment is unduly "profitable and continuous," there is likely to be something wrong with the engine. The fact is that the engine manufacturing industry to-day is faced with the need to do everything possible to increase the availability of engines, minimise the demand on maintenance men and reduce the overall cost of operation, including cost of replacement parts. One has the impression that Professor Maleev has set out with the object of putting into the hands of the engine operator the theoretical and practical information likely to be most useful to him should he be left entirely on his own resources. There is, for example, a great deal of information and advice—even warnings—in the chapters on "Fuels and Combustion," "Lubrication and Lubricants" and "Engine Lubrication." Professor Maleev looks upon lubrication as the most vital of all the details of diesel power plant operation. "Regardless (he writes) of how well an engine is designed from the standpoint of thermal efficiency and strength, and how well it is built from the standpoint of materials and workmanship, if the lubrication of all moving parts is not taken care of properly, the engine will either not run at all or show heavy wear and have a short life." Dealing with the cooling of lubricating oil, the author, while emphasising the need for carrying away heat generated by bearing friction, points out that the heat which may be dissipated in the oil cooler does not all originate in the bearings. Blow-by gases and heating of the metal parts by conduction are mentioned, and it is certainly very urgent that there be adequate heat-dissipating capacity in the oil cooler. The selection of oil cooler and its position relatively to the engine should be influenced, moreover, by the degree of convenience with which it can be kept clean in service. On fuel injection Professor Maleev stresses the accuracy in timing and in precision of manufacture, which is imperative where the injection of fuel may have to be completed (depending on the engine r.p.m.) within 1/600 second. While it is true that the specialised manufacture of fuel injection pumps has produced equipment of outstanding accuracy and quality of finish, the tendency of the times is both to multiply the number of fuel pumps per engine and increase the engine r.p.m. If an example be taken in a sixteen-cylinder four-cycle traction type engine operating at 750 r.p.m., there will be 6·25 injections per cylinder per second and $6 \cdot 25 \times 16 = 100$ injections per engine per second. It is manifest that if trouble is to be avoided there must be a superlative order of fuel filtration as well as extreme care in avoiding leakage of fuel into the lubricating oil. This is to say nothing of the grade of fuel, on which point Professor Maleev remarks that "Low-speed diesel engines can operate on almost any liquid fuel, from kerosene to Bunker C oil. Modern high-speed diesel engines, owing to the short time interval available for combustion at each

cycle, require a more special, comparatively light fuel oil."

On the subject of crosshead guides the author writes that "In double-acting engines the side thrust is taken by the crosshead slipper and its guides." This type of construction is not, however, confined to double-acting engines, but is much used on large single-acting slow-speed two-cycle engines of British and Continental manufacture. It is also used in single-acting engines of American design as, for example, the large Nordberg two-cycle engine. In very recent times the crosshead design has appeared again on high-powered pressure-charged single-acting four-cycle engines and with the tendency to the use of the so-called bunker quality fuel oil, the advantages of crosshead construction are much enhanced. Of these advantages economy in lubricating oil over the service life of the engine is something which has to be remembered along with the desirability of complete separation of the combustion chamber and crankcase. As a commentator of great experience has lately remarked, there are only two ways of meeting the difficulties of operation on bunker fuel: "Either a sharp limitation of the properties of the fuel or to build an engine insensible against the destructive constituents of the fuels."

Professor Maleev has included with his twenty-six well-illustrated and carefully indexed chapters a useful appendix containing a glossary of terms used in connection with engine work generally. Elsewhere in the volume a real effort has been made to expound, in plain English, the causes of vibration and the meaning of such expressions as "natural frequency," "critical speed," "torsional vibration," &c. Reading this book will certainly bring home to the engine operator the truth of those words which we find near the end of Carnot's "Réflexions": "The economy of the combustible is only one of the conditions to be fulfilled in heat engines. In many cases it is only secondary. It should often give precedence to safety, to strength, to the durability of the engine."

Hydraulic Operation and Control of Machines. By IAN MCNEIL. London: Thames and Hudson, Ltd., 244, High Holborn, W.C.1. Price 35s.

THE word "blurb" may have found its way into the English language and the Oxford Dictionary, but the "Publisher's eulogy" on Mr. McNeil's book is more than usually irritating. It is not reasonable to claim that "there is probably no branch of Engineering in which the literature available to the engineer is so sparse and so widely dispersed as that covered" by the book. The seventy-odd references in the "Select Bibliography" at the end of the book, including modern books by Ernst, Hadekel, Conway and Town, provide the answer. The publishers go on to claim that "for the first time a comprehensive picture" has now been written, "never before" having been available. But, no doubt, the author himself has been embarrassed by his publisher's enthusiasm, for the book does not set its sights so high.

The book sets out to fill a gap, more or less large according to opinion on the merits of existing literature, in published books dealing with the application of hydraulic equipment to machinery of various kinds. With this more limited objective it achieves some success and records much data on the heavier applications on presses and machine tools. It also includes data on marine and agricultural applications, although the treatment of aircraft equipment is very cursory. Some references are made to early work by the pioneers (Bramah, Maudsley, Armstrong, Tweddell, &c.) and to some of the more unusual developments of Constantinesco, Föttinger, &c. The chapters on forging presses, extrustion machines, deep-drawing and stamping presses, machine tools, and moulding and die casting machines are among the best in the book. Sections on pumps, accumulators and fluids are adequate and useful. But the chapter on aeronautical and marine uses strikes this reviewer as poor, and that on valves as disappointing, and indeed erroneous in places.

The insensitive reader who is not over-critical of the style of engineering textbooks will find the book of value. But it will be a pity if others find its prose sufficiently irritating to stop them reading the book. In an age of technical specialisation, the desire to take care in writing English may be dying. Was it really necessary so much to overwork the word "such"? It occurs on one page four times in nine lines, ("Such a pump is not balanced"—"Such pumps are regenerative . . ."). The meaning of some sentences might have been made less obscure: "These laws seem perhaps obvious to-day in the light of familiarity with the phenomena they conduce"? It is irritating, too, to encounter so many inverted sentences; for example, "from the general aspect of leakage, there has been some prejudice among users against oil systems" (page 142), or "where the valve element is cylindrical and slides over a similar cylindrical member containing the port the valve is a sleeve valve" (page 77).

In spite of these criticisms and in fairness to an author who has obviously put a great deal of hard work into the book, it must be repeated that within its proper limitations the book contains much of value to many engineers and designers. The printing is good and the diagrams are mainly clear.

Telecommunications. By A. T. STARR. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 35s.

THE term "telecommunication" is defined in the British Standard Glossary as "any telegraph or telephone communication of signs, signals, writing, images or sound of any kind, by wire, radio, or other system of electric or visual signalling." Thus it will be seen that the subject of "telecommunications" covers a very wide field. It is of such importance to engineering that it is included as one of the subjects in Part II of the London B.Sc. (Eng.) examination, and in the examinations for other university degrees. Dr. Starr has written a book with this title which is published in the Pitman Engineering Degree Series.

An introductory chapter on "Communication Systems" outlines the basic principles involved in the transmission of telegraph and telephone signals. Speed and band width for the former and methods of modulation for the latter are considered. There is brief mention of radio position and direction finding.

The "Elements of Telegraph Systems" are considered in more detail in the next chapter, which covers morse telegraphy and machine telegraphy, and includes a description of the mechanical operation of a Creed teleprinter. The main features of carrier telegraphy and picture telegraphy are given. The effects of the electric properties of the cable on the distortion of the signal are discussed, including the special problems of submarine systems. Before a corresponding treatment on telephony there is a chapter on "Acoustics, Microphones and Reproducers." It contains the standard mathematical treatment of sound waves with consideration of reflection, absorption, reverberation, interference and resonance. There is a rather brief treatment of electro-acoustics and it is noted that there is no mention of such important terms as "transducer" and "compliance." The various kinds of microphones, telephone receivers and loud-speakers are described with the theory of their operation. In the chapter on the "Elements of Telephone Systems," there is, first of all, a description of the component parts that are used in telephone exchanges—such as keys, relays and transmission bridges—and then, to illustrate the technique of this very large subject, examples are given of the circuitry and working of telephone instruments and magneto, C.B. and simple automatic exchanges.

One of the most important parts in the theory of telecommunications, "Lines and Transmission Networks," is afforded a very thorough treatment. It follows conventional lines. Useful inclusions are the use of linear parameters and matrices for four-terminal network calculations and practical approximate treatment of loaded line theory. The chapter ends with tabulated details of constant-k and m-derived filters. The results for the former are obtained; for the latter, only quoted. There are other occasions in the book where formulæ and equations are given with no indication as to their derivation. It is thought that the engineering student, for whom the book is primarily intended, would not wish to accept results without proof. If such proofs are beyond the scope of the book, they could be covered by references. The author's own textbook on *Electric Circuits and Wave Filters* would provide all the necessary references for the theory of filters.

The electronic aspect is met by a chapter on "Telecommunication Circuits," which, after a brief outline of valve theory, covers amplifiers, oscillators, modulators, detectors and frequency changers. Two important subjects which are well treated are negative feedback and noise. Carrier telephony, which makes use of both active and passive elements, is treated in logical order in the next chapter on "Line Telephony." The essential principles are explained by descriptions of two types of Post Office carrier systems. It would have been more logical if voice frequency telegraphy had been postponed until this stage instead of its inclusion in an earlier chapter before filters and valve circuits had been covered.

The "Basic Principles of Television," which follow, explain the idea of scanning, describe the main devices used to convert a picture into an electrical signal, and outline the functioning of a television receiver with circuit details of the chief components.

A single chapter is devoted to "Electromagnetic Waves, Radiation and Aerials," usually the subject matter of a complete book. The M.K.S. system is introduced; the fundamental laws of electromagnetism are reviewed leading up to Maxwell's equations in vector form; the basic theory of ionospheric propagation, radiation and aerial arrays is given. A number of important subjects are dealt with in a final chapter entitled "Microwave Technique." The essential features of microwave oscillators, including the magnetron and klystron, are described. There follows a brief description of the theory and use of waveguides and radiators for these frequencies with tables listing the properties of some modes in rectangular and cylindrical waveguides. The theory of the circle diagram and of its construction in both cartestian and polar form, is given. Brief mention is made of microwave measurements of frequency and power.

There are nine appendices which occupy

a considerable portion of the book and cover the following subjects :—" Mathematical Formulæ," " Steady-State A.C. Theory," " Power Level : Decibel and Neper," " Star-Mesh Transformation," " Fourier Analysis," " Distortion and Time Delay," " Operational Calculus and Laplace Transform Method," " Vectors and Maxwell's Equations," " Waveguide Theory." Of these the last five named deserve special mention. A knowledge of the mathematical processes contained in them is essential for a full understanding of many telecommunication problems. Their inclusion adds greatly to the value of the book.

In 450 pages Dr. Starr has produced a comprehensive book embracing the whole field of telecommunications. To achieve this the book is written in a succinct style with economy of description and explanation ; at the same time, accuracy, clarity and completeness are not sacrificed. The book is well produced with clear diagrams and good layout of the mathematical analysis. It constitutes an admirable textbook for the London B.Sc. (Eng.) examination in this subject and fully covers the syllabus. As a help to the student after each chapter there are questions taken from past London University examination papers with numerical answers at the end of the book. It is not only to the engineering student that the book will have an appeal. So much useful subject matter is contained in it—particularly in some of the appendices—that it takes the form of a valuable reference handbook for those concerned with any aspect of telecommunications. Both as a textbook and as a handbook it is strongly recommended.

SHORT NOTICES

Silver Plating. London : Johnson, Matthey and Co., Ltd., 73–83, Hatton Garden, E.C.1. Publication No. 1851 (free on request).—The object of this booklet is to give a brief and practical outline of the various operations which occur in silver plating. Irrespective of the particular application, these can be classified as preparation, plating and finishing, and the booklet deals with them under these headings. While the importance of polishing both before and after plating is emphasised, it is considered to be outside the scope of the treatise and is therefore not discussed in detail. Among the preparatory operations, the cleaning of the base metal is of prime importance and is dealt with not only as regards the more usual metals, such as iron, copper and copper alloys, but also zinc, lead, tin and aluminium, and their alloys. The main section contains both compositions and plating conditions for undercoats and silver plating, both in vats and by the barrel method. Silver plating is generally considered a straightforward process, but troubles, nevertheless, do occur. A discussion of these and their remedies is likely to be particularly helpful to the newcomer, while useful information is contained in two appendices.

Third International Conference on Hot Dip Galvanising held at Oxford, 4th–9th July, 1954. Oxford, 1954 : Zinc Development Association, Lincoln House, Turl Street, Oxford. Price £2 2s.—The third international conference on hot dip galvanising, which took place in Oxford last summer, was attended by 230 delegates from Europe and the U.S.A. In the present volume are presented the papers read before the conference, and the discussions which took place. After a survey of the industry and of recent trends follows a chapter devoted to sheet and strip galvanising, with further chapters on the galvanising of tubes, wire and threaded parts, modern heating techniques, control of dross formation, galvanised structures, and after-treatments. Two chapters of particular interest are those dealing with the costing of general work, and with questions of incentives and productivity. In this country alone, galvanising is carried on in 300 works and uses each year over 100,000 tons of zinc. During and since the war, the industry has been under pressure due to metal shortages and competition from light alloys. A considerable amount of modernisation has taken place and a better understanding of many of the technical and economic problems involved has been achieved. This symposium forms a useful work of reference for anybody concerned with the galvanising industry and the application of its products.

Mackrow's Naval Architect's and Shipbuilder's Pocket Book. Fifteenth edition. Revised by Lloyd Woollard, M.A., M.I.N.A. London : The Technical Press, Ltd., 1, Justice Walk, Lawrence Street, S.W.3. Price 55s.—This pocket book, which was first published in 1878 and last reprinted in 1946, has provided those connected professionally with shipbuilding with a compact volume containing all the ordinary formulæ, rules, and tables required for various calculations concerned with the design of ships. These formulæ and data are contained in a number of textbooks, but by being made available in convenient form between the covers of this pocket book information on a variety of problems is ready to hand and much time and trouble in searching for references is saved. Since the last edition was published the extensive progress made in shipbuilding and ship design has necessitated a substantial revision of the text and the addition of new material. Such revision takes account of new materials for ship construction, such as aluminium alloys and plastics, notes the modified tests for steel and other materials and the extensions to the Ministry of Transport regulations regarding accommodation, fire protection and watertight subdivision. The amendments and additions to Lloyd's Rules are included, together with Admiralty requirements and general information on welding. A storehouse of information is contained in the book, including data on such diverse subjects as the powering of ships, propellers, rolling, the latest stabiliser device, stability freeboard, ventilation, strength, and the properties of launching greases. This fifteenth edition maintains the continuity apparent throughout all the previous editions, a point of importance to those to whom the pocket book has long been a source of ready reference.

The Light Metals Handbook. Two volumes. By George A. Pagonis. London : Macmillan and Co., Ltd., St. Martin's Street, W.C.2. Price 63s.—This book has been written by Mr. Pagonis, of the Light Metals Research Laboratory, San Jose, California, to provide research workers, development engineers, fabricators, founders, &c., with complete data on aluminium and magnesium alloys. The first volume covers the text matter and the second volume, which can be used simultaneously, contains the relevant tables. Each volume is divided into two parts covering magnesium and magnesium-base alloys, and aluminium and aluminium-base alloys. Under each of these headings sub-sections deal with magnesium or aluminium-base alloys, their classes, mechanical and physical properties, mechanical properties at elevated and low temperatures, detailed properties of individual compositions, choice of alloy, casting characteristics, formability, heat-treatment, corrosion, machinability, and joining methods.

World Railways, 1954–55. Third edition. London : Sampson Low's " World Railways," Ltd., 25, Gilbert Street, W.1. Price £4 4s.—The new edition of this reference book gives a comprehensive record of the developments and trends in rail transport in all parts of the world. It provides a complementary volume to the previous edition, which dealt more fully with the types of locomotives and rolling stock in service on the railways. The space saved by omitting the information on motive power and rolling stock has been devoted to a number of new sections concerned with underground railways, locomotive and rolling stock manufacture, diesel engines, and special descriptive articles. The first section of the book dealing with railway systems gives up-to-date particulars of more than 1500 railways in 108 different countries, including details of their finance, traffic, and track. The new section on underground railways in addition to dealing with existing systems gives notes on proposed new lines. The organisation and products of some 170 builders of locomotives and rolling stock of all descriptions in this country and abroad are given in a separate section, together with illustrations and notes on their most recent equipment. In view of the increasing interest in diesel engine powered locomotives and railcars the new section on diesel engines is of value. It gives technical details with tabular data on the engines made by a large number of manufacturers building engines specifically for rail traction purposes.

Reinforced Concrete Arch Design. By G. P. Manning, M.Eng., M.I.C.E. London : Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 30s.—This is the second edition of a book first published in 1933, which outlines a method which, it is claimed, if followed step by step, will give the most economical shape and thickness of a reinforced concrete arch, in any given design case. Values are given for influence lines for a complete range of arches of different shapes and thicknesses. The examples and figures are generally based on the common small and medium spans, and the solutions are found by slope-deflection methods, but piled abutments and continuous arches are treated by displacement methods and the flexible arch by an energy method.

Dictionary of Railway Signalling and Telecommunications. By Dr.-Ing. habil W. Schmitz. Frankfurt a.M. : Dr. Arthur Tetzlaff-Verlag, Niddastrasse 64. Two volumes : English-German, German-English. Price DM. 12,60 each volume.—The " Englisches Woerterbuch fuer Eisenbahn Signal-wesen und Fernmeldetechnik " was first published in 1941 and is in the nature of a pocket dictionary, each volume containing some 9000 terms from the field of railway signalling and telecommunications, as well as general terms which have applications in these fields. In order to keep the bulk to a minimum, terms the meaning of which is obvious have been specifically omitted. The words were taken from both English and American literature and many terms of recent origin have been incorporated in the present revised edition.

Surveying and Levelling for Students. By Bernard H. Knight, D.Sc., M.I.C.E. London : Contractors' Record and Municipal Engineering, Lennox House, Norfolk Street, W.C.2. Price 18s.—This volume is intended as a textbook, particularly for the first examination of the Royal Institution of Chartered Surveyors, and its primary aim is to show how to combine the fieldwork and office work necessary to produce the required plan or section. Description of instruments has been reduced to those considered fundamentally necessary, and generally the text deals only with the kind of work likely to be required from the ordinary practitioner in this country.

Surveying : Solutions to B.Sc. (Eng.) Examination Questions, London University, External. By D. H. McPherson, M.I.C.E., and P. N. Ray, M.A. London : Macdonald and Co. (Publishers), Ltd., 16, Maddox Street, W.1. Price 18s.—The authors point out that, in spite of the value of illustrative examples in teaching surveying, there has been a paucity of such material. Hence, the present volume was published ; it is intended for students studying to degree standard, and particularly for the student working at home on his own. The subjects treated are : instruments, their adjustment and base line measurement ; areas and volumes ; levelling, traversing and tacheometry ; triangulation ; circular, transition and vertical curves ; underground and photographic surveying ; survey adjustment ; spherical trigonometry, and astronomical observations.

Building Construction. By W. B. McKay. London : Longmans Green and Co., Ltd., 6 and 7, Clifford Street, W.1. Price 45s.—Three volumes on various aspects of building construction have been combined in a single volume in this new edition. It describes the following aspects of building construction :—brickwork, masonry, carpentry, joinery, slating, plumbing and mild steel sections.

Electrical Engineers' Exhibition

No. II—(*Continued from page* 351, *March* 11*th*)

LORD CITRINE, chairman of the British Electricity Authority, opened the fourth Electrical Engineers' Exhibition, sponsored by the Association of Supervising Electrical Engineers, at noon on Tuesday last. The exhibition will close to-morrow, Saturday.

In a short speech at the opening ceremony Lord Citrine said that the exhibition, which occupied the whole of the ground floor at Earls Court, was the largest electrical exhibition ever staged in this country: 243 exhibitors were participating, compared with seventy in 1952, when the show was open for two days. Emphasising the importance of Britain's overseas trade, Lord Citrine said that the exports of electrical plant and appliances last year rose to a total value of about £216,000,000. It was axiomatic that a sound export trade could only be built up on a firm and durable home market. There was every sign that the home demand for electrical goods was continuing. The expansion was reflected in the electricity supply industry and the consumption of electricity had increased by 11 per cent in 1954; in that year 66,000 million units were sold and supplies were given to about 500,000 new consumers. By 1960 the annual rate of increase in generating capacity should reach about 2000MW and in 1960–61 the first two of the twelve atomic power stations, envisaged in the recently announced £300,000,000 programme, should come into operation.

After the opening ceremony silver plaques, awarded by the Association of Supervising Electrical Engineers for the best industrial and domestic exhibits on show, were presented to the winners by Mr. Bryan Donkin, president of the Association. The "domestic" award went to Ferranti, Ltd., for its "Fridge-Heater" heat pump, which was one of the equipments described in our issue last week. On the industrial side the award was made to the Record Electrical Company, Ltd., for its portable graphic recorder with clip-on transformer; it is among the exhibits described below.

General Electric Company, Ltd.

A new range of G.E.C. fractional horsepower motors is shown by The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. They are designed to comply with B.S. 2048 : 1953 and are mechanically interchangeable with other makes of motor that comply with this specification. With the exception of the flange-mounted machines, these motors are also interchangeable with American motors made to the American N.E.M.A. standard. To ensure maximum rigidity of construction the stator laminations are accurately stacked and riveted under high pressure, the ends of the stator pack being finally spigoted true with the bore for mounting the bearing brackets. A one-piece pressing screwed securely to the stator ensures correct centre height and accuracy of alignment of the foot-mounted motors. If silent operation is required, a rigid pressed steel base is used, which supports the motor from the nose of the bearing brackets (Fig. 5); these brackets are fitted with resilient end rings, resistant to oil and ageing, which absorb vibration and ensure quiet operation.

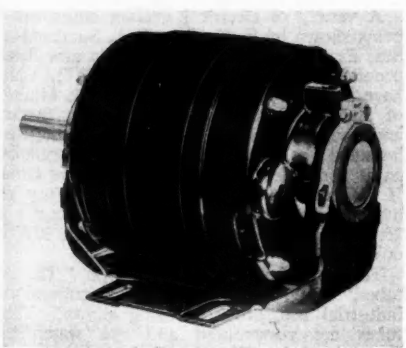


Fig. 5—Split-phase-start fractional horsepower motor fitted with sleeve bearings and resiliently mounted—G.E.C.

Among the motors designed for special purposes which this company is exhibiting is a 1500 h.p., 3·3kV, 2950 r.p.m., squirrel-cage motor for driving power station boiler feed pumps; it can be seen in the "Motor Way." Feed pump motors of this kind are specially designed to operate with limited slip for a specified time at 70 per cent of normal voltage. The motor exhibited is a pipe-ventilated machine which is arranged to operate with ventilating fans installed below the turbine room floor. To allow for end play in the coupling, expansion of the pump rotor and wear of the pump thrust collar, the squirrel-cage rotor is free to move axially in its bearings.

A new design of G.E.C. cubicle mounted group starter board for marine service is also being shown. The cubicles are of contemporary style, being adaptations of fully enclosed and protected switchgear that was originally developed for industrial use. No supporting framework is necessary and the unit construction enables cubicles up to 6ft 6in high to be assembled in standard widths from 1ft 6in to 3ft 6in. The cubicles will accommodate manually or electrically operated circuit breakers, fuse switches, contactors, isolators and instruments.

George Ellison, Ltd.

A new design of direct-to-line oil-break starter and circuit breaker is being shown by George Ellison, Ltd., Perry Barr, Birmingham, 22b. This equipment, which is illustrated in Fig. 6, is suitable for voltages up to 660V and is rated at 20A maximum. A built-in isolator is interlocked with the starter and can be provided with h.r.c. back-up fuses and auxiliary switches. The links forming the switches can be replaced by fuses to give protection to external circuits. The contact assembly, comprising a "scissor" mechanism with "heel and toe" contacts, is particularly designed for direct-to-line starting. For working in sequence, starters can be fitted with auxiliary switches and no-volt, no-close devices. Over-current and under-voltage protection is afforded by solenoid-operated releases fitted with "Ellison" "Triple-action" time lags. Mounting can be on pedestal (as illustrated) or wall or a group of starters can be supplied mounted on a busbar chamber in single or double tiers.

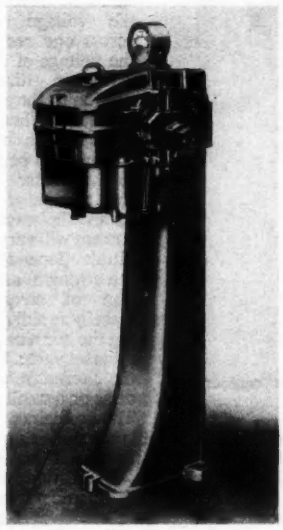


Fig. 6—Direct-to-line oil-break motor starter and circuit breaker rated at 20A up to 660V—Ellison

This starter has been A.S.T.A. tested successfully with h.r.c. back-up fuses mounted in the isolator and has a proved breaking capacity of 33,000A at 600V, equivalent to 25MVA at 440V and 34MVA at 600V. It has also been A.S.T.A. tested successfully without back-up fuses on a duty cycle in compliance with B.S. 936 : 1940, and has a proved breaking capacity of 1·5MVA at 600V.

Another item of interest on this stand is a modified version of the Ellison oil-cooled rotor starter for slipring induction motors. The new arrangement of the correct-starting-sequence device should make the new equipment more suitable for service in dirty or dusty surroundings.

Metropolitan-Vickers Electrical Company, Ltd.

Among the motors to be seen on the stand of Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester, 17, is a 45 h.p., 1470 r.p.m., special flameproof squirrel-cage motor for driving Lobbe Hobel coal ploughs and Panzer conveyors, which are made in Germany and are now being used by the National Coal Board. The main dimensions of this motor

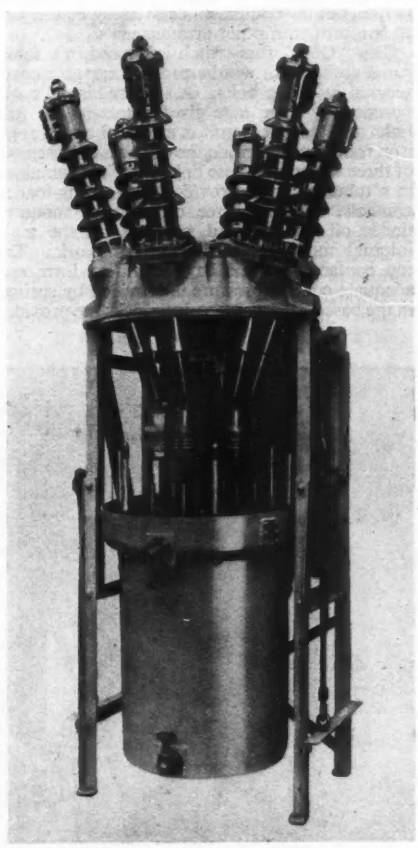


Fig. 7—33kV, 750MVA outdoor oil circuit breaker with tank lowered to show arc control chambers —Metropolitan-Vickers

are identical with those of the corresponding German machines which are normally used for these drives. In the Metropolitan-Vickers machine additional ratings are available on the same frame size from 30 h.p. to 50 h.p. at 1570 r.p.m.

Another interesting machine is one of a range of motors specially developed for oilfield beam well pump duty. It is a 30 h.p. eight-pole, high-torque, splashproof, squirrel-cage motor, built to American N.E.M.A. standards. Corresponding ratings for four-pole and six-pole speeds are also available or are being developed to make this range of motors suitable for other applications.

In the "Motor Way" display the company

shows a 35 h.p., 525 r.p.m. "MDX" d.c. motor designed for use in iron and steel works. Outputs from about 7½ h.p. to 200 h.p. are covered by the "MDX" range of motors, all of which are designed to conform with the "600 series" standards of the American Association of Iron and Steel Engineers.

Switchgear is represented on the company's stand by an "LG1" 33kV outdoor oil circuit breaker designed for a normal current of 400A and 800A, three-phase, 50 c/s, and a breaking capacity up to 750MVA. The total break time is 5 cycles. As illustrated in Fig. 7, the three phases are enclosed in one tank, which is raised and lowered by means of two "Pul-lifts" and slings. The circuit breaker contacts are solenoid-closed and the connections to the external circuits are taken through the tank lid via oil-filled spring-loaded condenser bushings. All the mechanism and local operation details are segregated in a weatherproof rectangular casing mounted on the angle-iron framework (on the opposite side to that from which the photograph, Fig. 7, was taken).

Ferguson, Pailin, Ltd.

An 11kV, 250MVA, ring main equipment for either indoor or outdoor duty is being shown by Ferguson Pailin, Ltd., Higher Openshaw, Manchester, 11. It consists of an "OFS" oil-immersed fuse-switch and two "IB3" oil switches. These three units are shown arranged in line, but the equipment can readily be adapted to conform with other arrangements.

The "OFS" fuse-switch is housed in a fabricated casing with weatherproof removable cover secured by fixing bolts. A smaller hinged cover fastened by wing nuts gives access to the fuse links and the whole unit is mounted on an angle iron framework. Inside the casing is an assembly of three replaceable fuse links; each is contained in a tubular carrier provided with spring-loaded contacts, and the three carriers are mounted under oil on insulated supports on the main internal moving mechanism framework. The top contact is of the bayonet fitting form and adequate contact pressure is provided by springs in the base of the carrier. Interlocks are provided to prevent closure of the fuse-switch, unless the top inspection cover (and, therefore, the fuse carrier) are correctly replaced in the service position, and to prevent opening of the inspection cover when the fuse-switch is in the "On" position. Normally, the compound-filled cable boxes are arranged for vertical entry of the cable from below, as illustrated, but alternative methods of entry can be provided for. When the unit forms part of a ring-main unit (as it does here) it is equipped with three busbars housed in a compound-filled chamber.

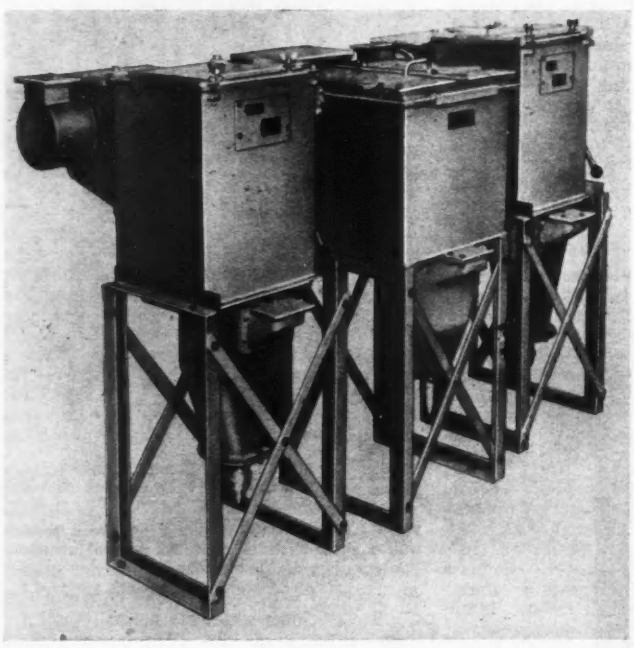


Fig. 8—11kV, 250MVA ring main equipment for indoor or outdoor service—Ferguson Pailin

Each of the two "IB3" three-phase oil switches has three operating positions, "On," "Off" and "Earth." When changing from the "On" to the "Off" position the handle is relocated and moved over the same arc as in changing from "Off" to "Earth." Inadvertent operation from "On" to "Earth" is, therefore, impossible. Padlocking arrangements are provided to allow the isolator to be locked in any of three positions.

Testing is done with the isolator in the "Off" position, prior earthing having been ensured by interlocks. Opening of the cover over the testing orifices does not give access to any live parts of the oil switch. After the cover has been opened the switch remains earthed until the test bushings have been earthed; the switch cannot be "On" as long as the test bushing orifice cover is open, whether or not the test bushings have been inserted.

The same company is also showing an electro-hydraulic operating mechanism designed primarily for operating isolators on the British Electricity Authority's 275kV super-grid. A number of auxiliary products, including rotary control switches, selectors and instrument switches are also being exhibited.

Brush Electrical Engineering Company, Ltd.

A self-regulating alternator (Fig. 9) embodying the "Amplidex" system of control* is one of the a.c. generating machines shown by Brush Electrical Engineering Company, Ltd. It is a 58/67·7kW salient-pole alternator, designed for a voltage range of 415/240V or 208/120V at 50/60 c/s and 1000/1200 r.p.m., the voltage regulation specified by the maker being ±2½ per cent for all conditions of loading temperature and power factor.

Excitation of the alternator is derived from an amplifying dynamic excitation system consisting of a main exciter and a small sub-exciter, both mounted in tandem in a single frame. The two exciters are connected in cascade. The voltage of the sub-exciter is determined by a simple voltage detection circuit in which the alternator voltage is fed through an isolating transformer to two bridge rectifiers, one shunted by a saturable reactor, and the other in series with a capacitor; the outputs from the rectifiers are applied to two resistances in series and the voltage difference across these resistance provides the error signal to the sub-exciter. The saturable reactor holds the voltage constant across one rectifier but the voltage of the other varies in direct proportion to the alternator voltage. When the two voltages are equal no current will be supplied to the exciter field. If the alternator voltage varies the exciter field current will vary in magnitude dependent upon the strength and direction of error signal, thereby rapidly correcting the terminal voltage to its set value. Setting of the alternator voltage is done on a small rheostat. The reference voltage provided by the saturable reactor is sensitive to frequency but so also is the current in the capacitor fed by the rectifier. These two effects are thereby cancelled out and thus no variation due to frequency changes results. Over the normal range of engine governing the balance point will remain unchanged; in fact the frequency can be adjusted from 50 to 60 cycles with only a small change in voltage. Compensation is needed to enable the exciter to operate with comparatively high armature loading and low magnetising power—a combination that results in large amplification and quick response. The compensating winding also helps to ensure good commutation during the field forcing that has to be applied to restore the alternator voltage quickly on sudden changes of load. There is also a damping circuit, whereby the maximum recovery rate can be maintained without instability.

* The Engineer, January 22, 1954, page 144

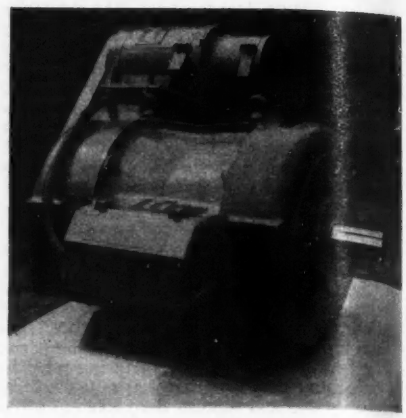


Fig. 9—Self-regulating alternator with "Amplidex" system of control—Brush

The alternator is of the normal salient pole construction with large air gaps and the ordinary ratio of field and armature ampere turns such as would be used with an automatic voltage regulator; it, therefore, has the same ability to cope with leading power factor loads. The field system of the main exciter is laminated and compensated, certain of the teeth being removed to form commutating zones; the stator is wound with concentrated excitation windings and a fully distributed compensated winding. The sub-exciter is a simple, separately-excited machine with a laminated field structure.

A recent addition to this company's products, an on-load tap-changing gear for transformers, is also on view, in the form of an equipment suitable for 33kV. It makes use of transitional switching with mid-point reactors and it provides up to twenty-eight values of voltage. Both manual and fully-automatic control are available.

A new product to be seen amongst the company's switchgear exhibits is an 11kV equipment embodying a circuit breaker fitted with a cross jet system of arc control.

E. K. Cole, Ltd.

A variety of electrical heating equipment is being shown by E. K. Cole, Ltd., Southend-on-Sea, Essex. These exhibits include new flameproof "Thermotubes" (type "FP"), which have been tested and approved by the Ministry of Fuel and Power Buxton Testing Station, and comply with B.S. 229. These fittings are intended for use in places (such as cellulose paint shop, petrol and oil stores) where Group II inflammable gases are present. They are made of heavy gauge steel tube in lengths of 2ft to 15ft, the loading ranging from 30W to 60W per foot.

The company's new "H" type "Thermotubes," which are designed for horticultural and industrial use, are also being shown. These tubes are rustproofed and are water-tight. Except that the tubes are of aluminium and the terminal chamber is of diecast construction, the tubes are similar in design to the standard "Thermotubes." Normally the loading is 60W per foot. Both the "FP" and "H" tubes, in the standard form, are suitable for 200/220V or 230/250V, a.c. or d.c., but tubes for 100V can be supplied to order. Another new equipment exhibited on this stand is the new "WT/45" water-tight thermostat which is designed to ensure economic operation of electrical space-heating installations in greenhouses

or other situations where dampness, water spray, or the likelihood of rough treatment, preclude the use of ordinary thermostats. The "WT" thermostat operates on a.c. supplies, has a maximum loading of 15A, and a temperature range of 35 deg. to 70 deg. Fah.

RECORD ELECTRICAL COMPANY, LTD.

A recorder, with a clip-on current transformer to facilitate metering of individual motors or feeders, &c., in service, without severing the main conductor, is being shown by the Record Electrical Company, Ltd., Broadheath, Altrincham, Cheshire. It extends the principle of the clip-on transformer and indicating ammeter to the field of recording.

The Graphic recorder (Fig. 10) consists essentially of a clip-on transformer connected to a rectifier moving-coil recording instrument having a full-scale deflection of 1mA. As illustrated, the clip-on current transformer is housed in a moulded case, with a hand grip

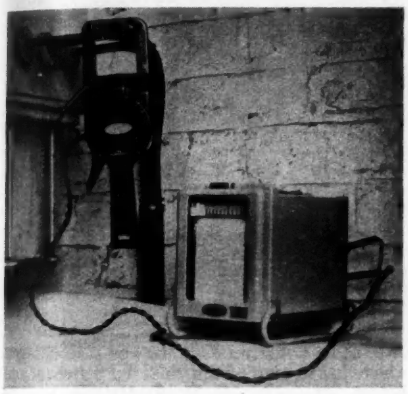


Fig. 10—Portable a.c. recorder with clip-on transformer—Record Electrical Company

and trigger operation of the movable limb. Cables up to 2¼in diameter can be accommodated by the aperture, and the case is insulated for voltages up to 600V.

A thumb-operated selector switch gives the choice of seven ranges (6-15-30-60-150-300-600A). Insulated secondary terminals are provided, together with a length of p.v.c. flexible cable to the recorder.

Normally the recorder is fitted with an eight-day spring clock, but a synchronous clock, suitable for 200/250V, 50 c/s, can be provided as an alternative. Chart speeds of 1in and 6in per hour are standard. Three self-contained voltage ranges of 150/300/600V, a.c., are incorporated, the resistances of these ranges being 1000 ohms per volt. Separate voltage terminals are provided, together with a change-over link which converts from amperes to volts as required. The chart is ruled into sixty linear sub-divisions.

(To be continued)

Laboratory Production of Pure Titanium Powder

ALTHOUGH titanium occurs abundantly in the form of an oxide in the earth's crust it is still relatively costly to produce as a pure metal. Among the manufacturing processes available for titanium and its alloys, melting and casting are naturally receiving much attention, and considerable improvements in technique and in the quality of the product have been made. Powder metallurgy is also being studied as a possible alternative or complementary method of manufacture. One of the difficulties associated with the powder metallurgy of titanium is that of obtaining the finely divided powder uncontaminated with oxygen or nitrogen. Pure titanium sponge, obtained by reduction of the tetrachloride by magnesium, is too malleable to be crushed into powder by virtue of its very freedom from these embrittling elements. Titanium powder produced by the reduction process is found to give rise to hard, brittle compacts after sintering in vacuo, due to the presence of oxygen and nitrogen in the powder.

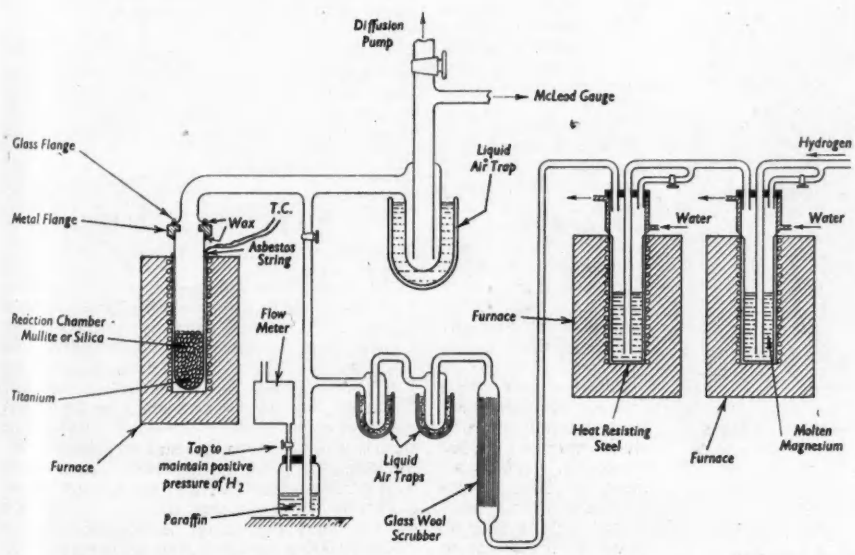
A method which avoids these difficulties has been developed at the research laboratories of The General Electric Company, Ltd.; it enables small quantities of titanium or titanium hydride to be produced in finely divided form substantially free from oxygen and nitrogen. The process consists of embrittling pure titanium sponge with hydrogen under carefully controlled conditions. The titanium hydride can then be sintered, hydrogen being evolved during the sintering process. Alternatively, the hydrogen can be removed by a separate vacuum treatment at temperatures up to 800 deg. Cent. to leave fine titanium powder.

The titanium sponge used as a starting material is selected on the basis of the hardness of a small sample prepared by arc-melting; the hardness should be less than 200 D.P.N. The elements of the process are outlined in the accompanying diagram: the sponge is first activitated by a short treatment of about five minutes at 700 deg. Cent. under a vacuum of 10^{-5}mm of mercury. It is then allowed to cool to 450 deg. Cent. and specially purified hydrogen is admitted to the reaction chamber. After hydrogenation of the sponge the apparatus is cooled to room temperature under a static pressure of hydrogen.

Early experiments using hydrogen purified by a conventional train consisting of potassium hydroxide, heated copper and phosphorus pentoxide gave unsatisfactory results. The sponge was quite brittle, but after crushing, pressing and vacuum sintering for four hours at 1200 deg. Cent. the resulting compacts had hardnesses in the range 270 to 320 D.P.N. The contamination indicated by these values was considered to have been caused by impurities in the hydrogen. Other methods of gas purification were, therefore, examined, including "gettering," by titanium sponge, diffusion through a palladium thimble, and regeneration of hydrogen from titanium hydride. The most convenient process, however, was found to be to bubble the gas through molten magnesium as shown in the diagram. Although the magnesium was maintained just above its melting point at 675 deg. to 725 deg. Cent., a glass wool scrubber was necessary to prevent magnesium vapour from being carried over by the hydrogen into the reaction chamber.

The titanium hydride prepared in this way usually contained from 3 to 4 per cent hydrogen by weight, and was shown by X-ray analysis to have a single phase crystal structure approximating to face-centred cubic, with a lattice parameter $a_0=4{\cdot}43$Å. The increase in weight calculated for the formation of the compound TiH_2 from titanium is 4 per cent, and the lattice parameter of TiH_2 is given as $a_0=4{\cdot}42$Å.

The hydrogenated sponge after grinding can be satisfactorily pressed and vacuum sintered to give hardness values of less than 200 D.P.N., provided that the powder is screened and the very fine (minus 300 mesh) fraction removed. This powder is naturally very reactive, due to its large surface area, and becomes superficially contaminated during grinding. The remaining hydride powder is quite stable over long periods and can be used as a base material for the preparation of massive titanium or titanium alloys by powder metallurgical methods.



Diagrammatic layout of apparatus for the embrittlement of titanium sponge with hydrogen

Small Laboratory Radiant Heater

CLEANLINESS and ease of control are claimed for the 300W laboratory radiant heater shown in the accompanying photograph. The apparatus is being manufactured by Electrothermal Engineering, Ltd., 270, Neville Road, London, E.7. It consists of a corrosion-resisting shell

A 300W electric radiant heater controlled by rheostat or energy regulator, for use in laboratories

with air circulation holes in the lower part and a heating element at the top. This element has a refractory aluminium oxide moulding in which is embedded the nickel-chrome heating wire. The refractory is hollowed out in such a way that the radiant heat is concentrated and directed to the centre top of the cavity. Temperatures of 800 deg. to 1000 deg. Cent. may be produced there, and used for heating test tubes, small flasks or crucibles. A cowl is provided for deflecting the heat away from the hand. The heater can be held in the hand either vertically or at an angle. Control is by energy regulator or rheostat.

Centreless Grinding Machine

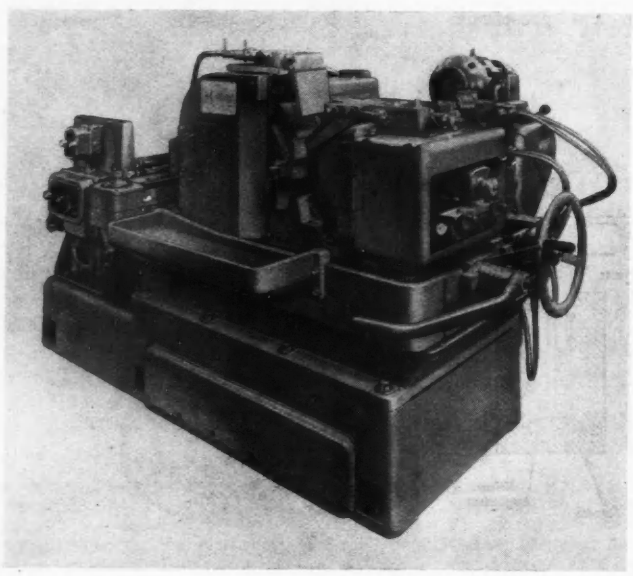
THE model "D" centreless grinding machine made for a number of years by Arthur Scrivener, Ltd., Tyburn Road, Birmingham, has now been superseded by the recently introduced No. 2 model "G" machine illustrated below. In the new machine, the fabricated steel base has been replaced by one of cast iron and a number of other changes have been made. The control head has a 12in diameter wheel, and a single electric motor driving through a gearbox provides the range of working speeds as well as the higher speed required for wheel dressing purposes. The workrest is coupled to the control head and is adjustable laterally in respect to the control wheel, and it advances and retracts with the head when plunge grinding. Parallel and cylindrical work from ¼in to 5in diameter can be ground on the machine and for straight-through work automatic feed attachments can be fitted. The standard machine has to be operated by hand when plunge grinding shouldered, tapered or formed workpieces, but for use where plunge grinding is mainly required the makers have developed a special, controlled cycle, automatic version of the machine.

The grinding wheel spindle runs in phosphor-bronze bearings, adjustable for taking up wear, and is driven through vee belts at 1000 r.p.m. by a 20 h.p. motor. This spindle takes wheels up to 20in diameter and 6in wide and provision is made to prevent change of the endwise location of the wheel as a result of expansion of the spindle due to heat during a long run. Permanent front end location of the wheel and spindle is ensured by means of a collar immediately adjacent to the wheel abutting against a large ball race, compensation for any variation in length due to expansion being provided by a spring-loaded thrust race at the opposite or rear end. The control wheel is driven through stepped belt pulleys and a gearbox by a 1½ h.p. motor. It has six working speeds from 11 to 56 r.p.m., and a truing speed of 335 r.p.m., and can be tilted to any angle up to 7 deg. to feed the work through the wheels.

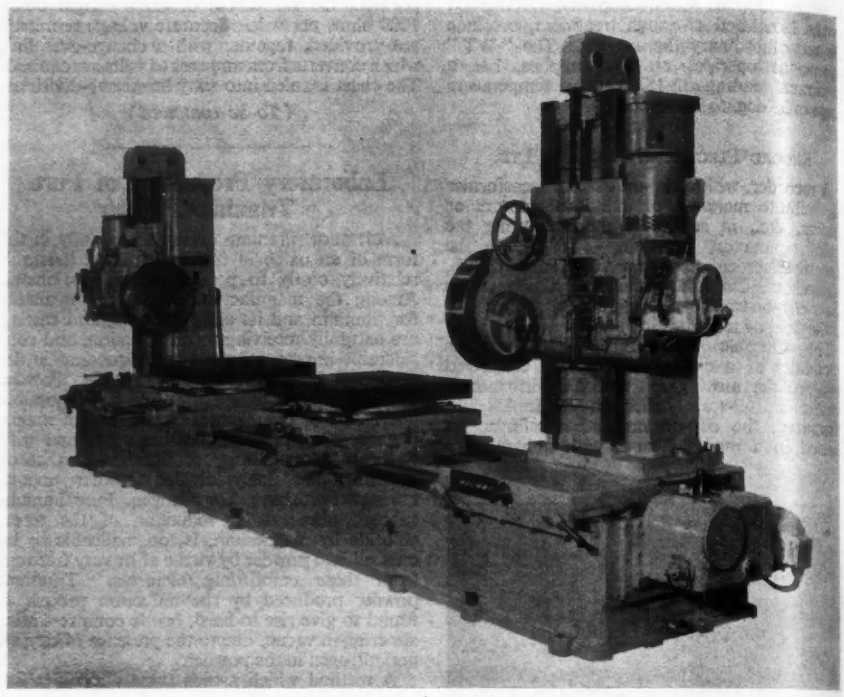
The universal workrest fitted makes it unnecessary to change the rest when changing over from a straight-through to a plunge-grinding workplate. Nine sizes of workplate for straight-through and nine sizes for plunge-grinding are supplied with the machine. A separate form truing attachment is provided for each wheel, that for the grinding wheel being similar to the one for the control wheel. The attachment for the control wheel is mounted on the fixed member of the head, so that the slide and its diamond always move in a horizontal plane substantially parallel to the grinding wheel, and no adjustment is needed to compensate for the varying angles of tilt of the control wheel. Both of the diamond truing slides are hydraulically operated.

If required, an automatic micro-sizing attachment can be supplied so that by depression of a push button the control head can be automatically fed forward in any required increments from 0·0001in to 0·0005in. An extension of this attachment is the fitting of a pneumatic measuring device through which the work coming from the machine is passed. This pneumatic device automatically actuates the micro-sizing attachment to compensate for wheel wear.

The controlled-cycle, plunge-grinding machine is similar to the above machine, except that a hydraulic pump and control gear are fitted as a unit and the straight-through guide plates are deleted. With this equipment a reciprocating cam plate enables any wheel opening movement up to 1in to be obtained, and through a follower the plate controls the amount of stock removal from the workpiece. The equipment has been designed for the hand loading of individual pieces or for magazine work feed.



Centreless grinding machine for parallel and cylindrical work from ¼in to 5in diameter



Duplex pipe flange facing machine with 24in diameter facing heads which can be spaced up to 14ft apart

Duplex Pipe Flange Facing Machine

A DUPLEX machine for facing pipe flanges, which has recently been built by Kitchen and Wade, Ltd., Arundel Street, Halifax, can be seen in the illustration above.

The columns carrying the facing heads are adjustable along the bed of the machine to suit varying lengths of pipe, and between the columns there are two 3ft square work tables, each of which can be adjusted transversely and longitudinally. The independently operated facing heads have a vertical adjustment of 2ft 9in on their columns and they can be spaced up to 14ft apart. Each 24in diameter facing head is driven by a 5 h.p. motor through a gearbox giving six speeds in three ranges—50 to 15 r.p.m., 90 to 15 r.p.m., and 88 to 25 r.p.m. By incorporating forward and reverse directions of feed to the facing heads cuts can be taken first outwards and then inwards across a flange to bring the facing slide back to its starting position.

The tables have three rates of power feed of ¼in, 1in and 1¼in in addition to a rapid power traverse of 10ft per minute for quick-setting purposes. Each table has four indexing positions arranged at 90 deg. and when set is locked by four clamps.

The controls for the heads are grouped for easy operation and push button control panels are arranged conveniently at the front of each column. Safety trips are provided for the traverses of the tables, columns, and facing slides.

Industrial Participation in the Development of Atomic Power

WE have received some information about the formation of an organisation which will be known as the A.E.I.-John Thompson Atomic Energy Group. It is composed of nuclear physicists and engineers drawn from Metropolitan-Vickers Electrical Company, Ltd., The British Thomson-Houston Company, Ltd., and the John Thompson group of companies, and its aim is to study the problems involved in the design of atomic power stations. The group has taken over new premises in the Manchester area and has started on the study and design of atomic energy power projects of the kind that may be included in the £300,000,000 programme recently announced by the Government.

Two Canadian Prestressed Concrete Bridges

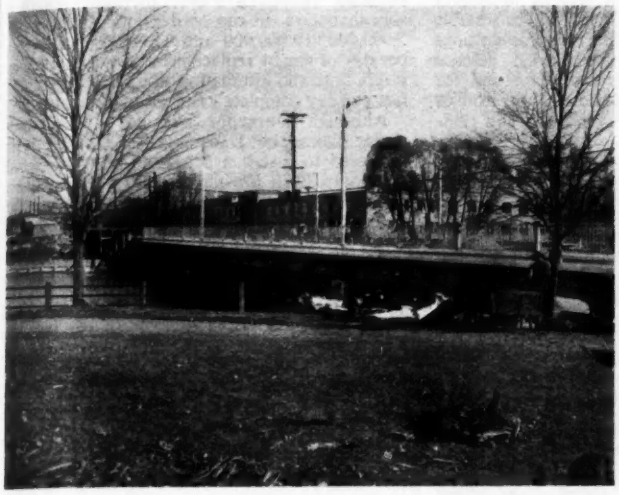
BY OUR CANADIAN CORRESPONDENT

ON November 10th last, the Queen Mother opened the first of the Bytown bridges over the Rideau River, Ottawa. Wide flange I-section prestressed beams are used exclusively to form the decks of the bridges ; each span is comprised of eighteen beams laid side by side to form a 65ft deck for each span, so 108 prestressed concrete girders are required to complete the two three-span structures. The bridges were designed to meet the Canadian Standards Association's Specification S6 : 1952, and each beam had to support half the specified axle load with a 30 per cent impact ratio. The precast beams of the south and north bridges are 75ft 6in and 89ft 3in in length, and with depth/span ratios of 1/20 and 1/22 respectively. The former bridges were still in existence during the early stages, and so the following procedure was chosen for the construction. New piers were erected under the old bridge deck, two piers for each bridge. Two prestressed concrete beams for each span were cast at the central casting yard. These beams were brought into position by using the old bridge deck and, by a blocking system, they were supported temporarily on the new piers. The old steel bridges were then demolished and the beams were lowered on the new piers, these beams then being used as a working bridge to place the remaining beams on each span. The bridge deck was then prestressed transversely and the superstructure completed. The Magnel-Blaton system of prestressing was used in the constructional operation.

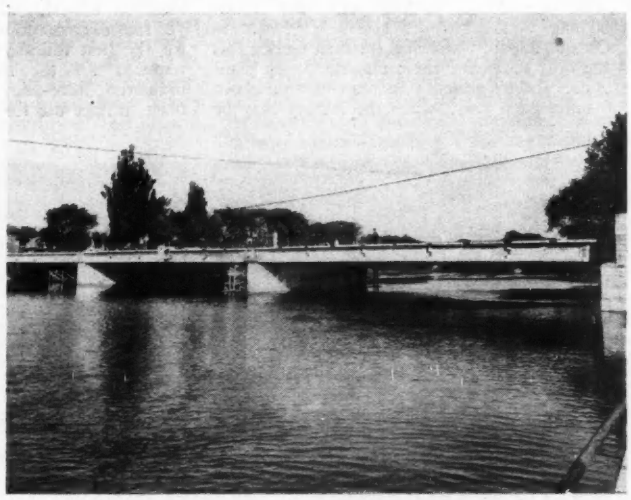
The piers had to be built during the winter so that all obstructions could be removed prior to the spring floods. At each of the two piers of the north bridge open cofferdams were erected, excavation then being completed and concrete poured. The south bridge required the blocking of the river to enable the erection of a steel sheet pile wall across the south channel on the upstream side. An existing log dam, downstream, was opened and the contractor was able to complete excavation and concrete work in the dry. The four piers were completed in eight weeks, before the start of the high spring flood waters.

A maximum weekly production of five beams per bridge was attained at the casting yard. The beams have a weight of approximately 36 tons, and during construction the first two in each span were supported on the temporary blocking system which was built through the deck of the old bridge from the new piers. It was after this that the demolition of the old bridge deck was carried out. The two beams were then lowered on to rails and, with the aid of two hydraulic jacks, moved sideways into position. The two beams formed a runway for the crane that took part in the demolition of the girders of the old bridges. As soon as the demolition was complete the trailers were used to bring further beams into position, which were again lowered on to the rails and moved to the sides. The transverse prestressing was then carried out, followed by longitudinal and transversal grouting, with finishing work on the bridge deck. Service pipes were placed under precast pavement slabs, so that the footpaths give easy access to them. In accordance with the requirements of the city, handrails of aluminium were provided and light posts and aluminium fascia sheets used on the exterior beams to give the bridges an attractive appearance.

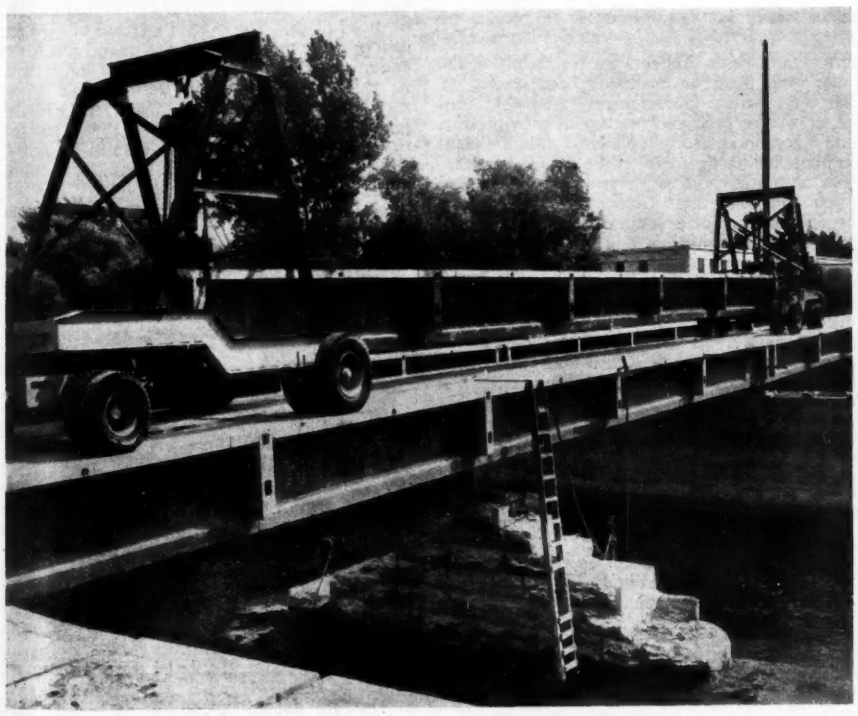
The general contractor for the bridges was the Key Construction Company, Ltd., Montreal, and the Precompressed Concrete Engineering Company, Ltd., was the sub-contractor for the prestressed work. The accompanying illustrations show the two bridges and the method used for transporting the beams from the casting yard to the site.



South Bytown Bridge over the Rideau River, Ottawa



North Bytown Bridge nearing completion



Transport of prestressed beam with two trailers

"ARGONAUT" WELDING PROCESS.—A new film has been made for the British Oxygen Company, Ltd., in which the "Argonaut" welding process is explained and the basic technical differences between it and the latest of the "Argon" welding processes, and "Argonarc" are compared. The manner in which a thin consumable electrode is used in conjunction with a high-density arc to give continuous, all-position welding is shown by high-speed photography which slows the action on the screen by 125 times. In this sequence the characteristics of the arc and droplet metal transfer are clearly shown. Slow-motion photography is also used to give a comparison of the use of argon and nitrogen as shielding gases. In addition to giving examples of the process in use on aluminium, stainless steel, copper and mild steel, the film gives an indication of the sections of metal on which the process can be used to advantage.

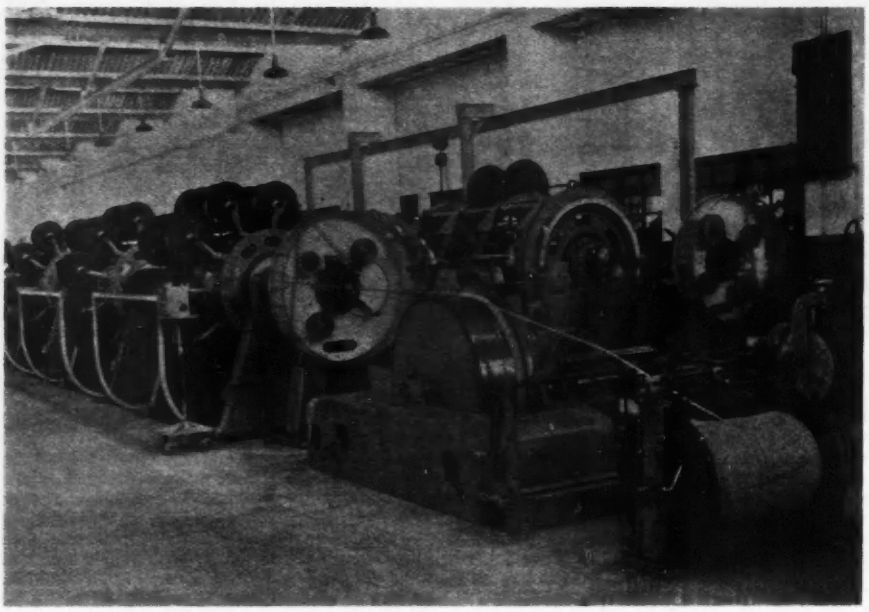
Indian Engineering News

BY OUR INDIAN CORRESPONDENT

Telephone Cables

The first telephone cable manufacturing plant in India went into production in December with the inauguration of Hindustan Cables, Ltd., at Rupnarainpur, near Chittaranjan, West Bengal. The factory, set up in technical collaboration with Standard Telephones and Cables, Ltd., of London, has an installed capacity for turning out 500 miles of telephone cables of different sizes every year; this year it will concentrate only on local or exchange area cables and then gradually take up the other varieties, including long distance audio frequency trunk cables and carrier frequency cables. The capital expenditure on the plant was about £800,000.

Outside Japan, which has six such works, this is the only telephone cable manufacturing plant in Asia. India's present requirements total about 500 miles each year, which the factory may be able to satisfy within a couple of years, but the demand is expected to go up to over 1000 miles very soon and plans are being made to increase production accordingly. Of the principal raw materials used in cable manufacture, copper wire, hessian and seasoned soft timber are available locally but steel tape, insulating paper and lead have at present to be imported from abroad. The cost of the home-made product is said to be about 25 per cent cheaper than the imported variety. The factory which receives power from the Damodar Valley grid, is equipped with up-to-date testing and quality control apparatus. Our illustration shows a cable stranding machine.



Stranding machine at Hindustan Cables factory in West Bengal

The factory is one of the several owned and financed by the Government of India and running under the overall control of the Ministry of Production. No private capital is associated with it. Among the other similar enterprises are the Sindri Fertilizer Factory, the Chittaranjan Locomotive Works, the D.D.T. plant at Delhi, the machine tool factory at Bangalore, the penicillin plant at Pimpri, near Poona, and the new steel plant at Rourkella. Most of these, except the last, are now completed or about to be completed. They represent a capital expenditure of about £100 million and form a fairly important part of what is known as the " national sector " of the Five-year Plan.

Durgapur Project

The Government of West Bengal has drawn up a scheme for the development of the Durgapur area in the Damodar Valley, known as the Durgapur Project, and is seeking the approval of the Government of India for its implementation. The project envisages the establishment of a chemical industry based upon the two main raw materials, (namely coal and iron) available in the area, and is said to be modelled on the Dutch State Mines Project of Linburgh, in Holland. The scheme is a major one and will be spread over a number of years, probably fifteen or so. The first phase, involving the manufacture of coke, tar, benzol and ammonia, gas and power development to the extent of 50MW to 60MW, will be taken up this year and is scheduled for completion in 1957.

In the first phase it is proposed to install a modern by-product coke oven plant capable of carbonising 1300 tons of coal per day, with provision for doubling the capacity. The selection of plant and coal will be such that 925 tons of coke produced per day will be suitable for the best foundry practice, e.g. for castings required for the locomotive works, defence industries, ferro-alloy production, &c., and for blast furnace use for production of pig iron or ferro-manganese. Tenders for the supply of the coke oven plant have already been invited by the West Bengal Government. About 45 tons of tar will be produced per day as a by-product and it is proposed to set up a tar distillation plant to manufacture light oils, carbolic oils, naphthalene anthracene oil, wash and heavy oils, and pitch and road tar. Later, it is proposed to process this tar for producing flotation reagents, high-quality germicides and raw material for synthetic resins, carbon black, lamp black, carbon refractories, and electrode carbon from pitch. The Durgapur plant is expected to produce about 10 tons of carbon black per day, approximately half the present requirements of the rubber industry. It is also understood that, as far as the manufacture of electrode carbon is concerned, the Fuel Research Institute has developed a process of extraction of coal with tar oils for production of ashless carbon and that pilot plant trials are now being planned. If this process is successful (and it is believed to have been successfully developed in Japan), then the combination of production of pitch coke and ashless carbon by coal extraction will be undertaken at Durgapur for meeting the entire requirement of electrode and ashless carbon for electrical and electro-metallurgical industries in India.

About 7,000,000 to 8,000,000 cubic feet of gas per day will be surplus in the initial stage at Durgapur after meeting the requirements of oven heating. Part of this will be absorbed for other heating purposes and for the manufacture of carbon black, and it is estimated that 6,000,000 cubic feet will still be surplus. It is proposed to utilise this surplus gas by supplying it to the industrial area around Asansol, where by 1960 it is estimated that the demand will be more than enough to absorb the surplus. Once the Durgapur Project is really under way oven heating is likely to be undertaken by " lean " gas and a further 7,000,000 cubic feet of gas per day will be made available for Asansol and Calcutta. When this stage is reached it is proposed to install producer gas plants for heating the coke ovens and release the oven gases for the Asansol industrial area as well as for the Calcutta area. The high-pressure pipeline will also act as a gas reservoir. When the demand exceeds 20,000,000 cubic feet per day, a complete coal gasification plant (with steam and oxygen) of the Lurgi pressure gasification design will be installed. Plans have been prepared in such a way that the load can be developed in stages of 5,000,000, 10,000,000 and 15,000,000 cubic feet per day of gas by replacement of oven heating in stages until the installation of a 20,000,000 cubic feet per day complete gasification plant.

Although Durgapur will be supplied with power from the Damodar Valley grid, it is proposed to install a 50MW to 60MW thermal station to burn low-grade coal and gas. This power station will be integrated with the coke oven plant so as to burn either pulverised coal or gas during the off-peak period when there is a surplus. Tenders for the supply of the steam and electrical plant have already been invited.

In the second phase of the scheme a low temperature carbonisation plant of 700 tons to 1000 tons per day will be installed, depending upon the quality of coal and tar yields. Associated with this, a tar distillation plant of 100 tons per day capacity is also to be installed. In the third phase, it is proposed to install two blast furnaces of 400 tons per day capacity, one to produce pig iron and the other ferro-manganese. It is hoped to integrate the production of pig iron and ferro-manganese with the coke oven plant so that with the availability of abundant power, manufacture of special steels and special quality pig iron can be undertaken and later the manufacture of special alloys and alloy steels and their rolling.

Power Production

By the end of 1953 the public electricity supply undertakings in India had an aggregate installed capacity of 2305MW, as compared with 2061MW in 1952, according to the Central Water and Power Commission's statistics released recently. Of the total, 1394MW consisted of steam plant, 731MW of hydro plant and 180MW of diesel plant. The overall increase of 11·8 per cent over the previous year was mainly due to the commissioning of the Bokaro power station with its three sets of 50MW, Basin Bridge power station (thermal) with two 15MW sets, Chandni power station (thermal) with three 15MW sets and the Moyar station of the Pykara hydro system with one 12MW set. The production during the year amounted to 6697 million kWh, of which 53·4 per cent was generated by steam plant, 43·5 per cent by hydro plant and 3·1 per cent by diesel plant. Eighty-three per cent of power was generated by undertakings with more than 100 million kWh annual capacity, and twenty-six undertakings with capacities between 10,000,000 and 100 million kWh produced 12·5 per cent of the total. Ninety-two per cent of the electricity production in the country was due to twenty-nine stations with installed capacity exceeding 10MW.

The *per capita* consumption of electricity varies from 0·49kWh to 77·91kWh per year, with Delhi recording the highest figure and Mysore and Bombay following closely. The average *per capita* consumption for the whole country was 15·47kWh, compared with 13·83kWh for the previous year. The figure for the average *per capita* production is 18·5kWh, which compares with 1288kWh for the United Kingdom, 2771kWh for the U.S.A. and 642kWh for Japan, the only Asian country with a higher figure than India's. If the generation of plants of industrial establishments and railways is taken into account, the figure (for consumption) would be about 24·3kWh per year.

The total capital expenditure on public supply undertakings in the country amounts to Rs.193·5 crores (£145 million), and the average revenue

per kWh sold for all purposes is estimated to be 1·084 anna (1·219d.). The accompanying table gives plant capacity and output statistics of the electricity supply industry for the years 1951–1953.

Electricity Supply in India, 1951-53

	1951	1952	1953
Plant capacity (kW) :			
Steam	1,097,567	1,176,317	1,394,232
Diesel	162,680	170,259	180,294
Hydro	575,179	715,179	731,179
Total	1,835,426	2,061,755	2,305,705
Output (million kWh) :			
Steam	2,779·059	3,102·416	3,572·792
Diesel	219·646	218·801	210·540
Hydro	2,859·698	2,799·130	2,913·855
Total	5,858·403	6,120·347	6,697·187
Maximum demand (kW) ...	1,205,194	1,310,651	1,416,350
Sales (million kWh)	4,793·344	5,005·682	5,597·083

Note.—Over the first nine months of 1954, the monthly production averaged about 600 million kWh, as compared with 550 million kWh in 1953.

Power from the Bhakra-Nangal Scheme

The first of the two power houses on the Nangal Hydel canal of the Bhakra-Nangal project, the Ganguwal power house, was opened by the President of India, Dr. Rajendra Prasad, on January 2nd this year. The power house is about 12 miles downstream of the Nangal dam and has an ultimate installed capacity of 72MW, of which 48MW have now been installed, but, so far, only one set of 24MW has been commissioned. It will supply power to New Delhi, and the states of Punjab, Pepsu and Rajasthan, besides helping in the construction of the 650ft-odd high Bhakra dam on the Sutlej. Work on the second power station at Kotla, 6 miles downstream of Ganguwal, is proceeding and the station should be completed by the end of this year. Of the three major multi-purpose projects now under construction in the country, the Bhakra-Nangal is the biggest, involving an expenditure of over £100 million and with power benefits exceeding 500MW. Work on the Bhakra dam proper is to begin sometime this year, probably after the monsoon.

Ganguwal is a low head power station, with a minimum head of 93ft. The work, begun in 1950, was complicated by the fact that the foundation concrete had to be laid 68ft below the subsoil water table. The foundation level of the power house proper as designed by Westinghouse, Ltd., was placed at RL.982,00, on a clay stratum that was found to be unsuitable for taking heavy loads. In order to avoid possible settlement and sliding, the foundations were taken down 22ft to RL.960,00 on a firm stratum of boulders, shingle and sand. These extra 22ft had to be filled over with a reinforced concrete raft of cellular design. As the average natural surface level at the power house site is RL.1075,00, and the subsoil water level RL.1023,00, the depth of excavation was 115ft, 63ft of which had to be through the water-logged strata.

The dewatering of foundations was done in three stages : (1) from RL.1023,00 to RL.1012,00 by open sump wells ; (2) from RL.1012,00 to RL.982,00 by well-points ; and (3) down to RL.955,00 by tube wells. The sinking of tube wells was necessitated by the nature of soil below RL.982,00, which, owing to its boulders, shingle and coarse sand, offered great resistance to well-points. Moreover, the artesian pressure below the clay layer did not permit the mud of the rotary rig to form mud walling around the drilled hole and the boulder cuttings could not thus flow out. The lowering of the artesian pressure was effected through shallow tube wells driven 25ft apart on the downstream flank of the raft. Deep tube wells were then driven between the shallow tube wells. The dewatering was begun in November, 1950, and the first concrete was poured on June 15, 1951. The dewatering was said to be so effective that the excavation slopes stood firm at ½ to 1 and ¾ to 1 even during the monsoons.

The raft foundation of the power house is 220ft by 120ft and 22ft 4in high. The structure consists of 4ft thick r.c. slab at the bottom and a similar inverted slab at the top held apart by cells measuring 12ft 2in by 10ft 6in by 14ft 4in high. All the dividing walls are 4ft thick except the walls between the units which are 9ft 2in and the end walls which are 7ft 7in. The raft is enclosed on downstream and upstream sides by steel sheet piles. The reinforcement involved in the structure is of the order of 1900 tons and the quantity of concrete amounted to 150,000 cubic yards. The total cost of the civil works, including foundations and superstructure, is approximately Rs.3.32 crores (£2,500,000).

The Kaplan turbines were supplied by the Baldwin Locomotive Works and are designed for 33,500 b.h.p. at 166·67 r.p.m., and a head of 98ft. The penstocks have a diameter of 19ft 3in and the flow is controlled by radial gates installed at the forebay regulator. Generators and allied equipment, including switchgear, have been supplied by Westinghouse, Ltd. The total cost of the electrical equipment, comprising two generator units, switchgear, power transformers, cables and their erection, is about Rs.3.23 crores (£2,400,000). Most of the civil engineering work was done through direct labour under the supervision of the engineers of the Bhakra Control Board.

African Engineering News

BY OUR SOUTH AFRICAN CORRESPONDENT

Union and Central African Federation Railway Developments

In order to keep abreast of demands, the South African Railways are being further developed. The Bloemfontein to Kroonstad line and sections of the Johannesburg to Durban line are being double-tracked at a cost of at least £14,000,000. On the Cape Western line, more crossing loops are being put in to increase the traffic capacity. Some important new lines have been built to service the coalfields and goldfields under guarantees from the industries they benefit. Of the many lines projected, the most interesting is the 170-mile branch line from Piet Retief in the Eastern Transvaal to Sordwana Bay, on the Indian Ocean, 200 miles north of Durban, where it is proposed to construct a new harbour. Large areas through which the line will pass will be irrigated. The South African Railways have over 13,000 route miles and 6 per cent of the total is now electrically worked, and it is proposed to extend electrification where possible. A large-scale programme of other improvements on the Rand and at Vereeniging is being carried out at the cost of about £23,000,000.

Since the formation of the Federation of Rhodesia and Nyasaland, the financing of railway development has become a Federal responsibility, and it has been officially announced that £17,000,000 will be spent on these services in the next three years. An outlet to the sea is the main problem of the Federation, and work is well advanced on the south-east trunk route which will give access to the well-equipped port of Lourenco Marques, and lessen the Federation's dependence on Beira. The completion of the delivery of twenty-three diesel-electric locomotives being supplied by The English Electric Company, Ltd., and the fifteen Beyer-Garratt locomotives from Beyer Peacock and Co., Ltd., of Manchester, the last five of which were expected at Beira in January last, will assist materially in speeding up services. Orders for several hundred trucks have been placed in the United Kingdom by the Rhodesia Railways, and with the £1,000,000 made available to them by the Rhodesian Anglo-American Corporation, 250 wagons have been ordered from the Metropolitan-Cammell Carriage and Wagon Co., Ltd., of Birmingham, with 200 to 300 more wagons to come, for the main purpose of carrying coal from the Wankie Collieries to the Corporation's copper mines in Northern Rhodesia.

Nyasaland and Central African lines last year carried five times the tonnage they handled in 1939. In East Africa the position is similar, in spite of setbacks to schemes of harbour construction, and dislocation caused by the Kenya emergency. The railways and harbours under the control of the East Africa High Commission's Railways and Harbours' Administration, have broken record after record in the amount of traffic handled on the 3000-mile system, the largest in the Colonial territories. Since 1948, capital expenditure of nearly £60,000,000 has been authorised, and the Board expects to need another £30,000,000 in the next five years.

The East African Railways and Harbours operate 6000 miles of inland waterways on the Great Lakes and Nile, and in 1953 the system carried over 300,000 tons of freight and 300,016 passengers. The road services operate over 1700 route miles and carry hundreds of thousands of passengers and a great amount of freight each year. Orders for new passenger buses, goods lorries and trailers from Britain are continuously being placed. In its last report the Administration states that it now has 350 locomotives of all kinds, and over 12,000 goods wagons, compared with just over 200 locomotives and 7600 goods wagons in 1939, while the figure of mileage has increased by over 170 per cent. With reference to Kenya, the possibility of electrifying the main line there is to be investigated, according to the East African Administration. Increasing pressure on Kenya's railway system resulting from rapid industrial development and the Mau Mau emergency has prompted such investigations, which relate to the main line from Mombasa to Nairobi. The development of hydro-electric schemes in Kenya and the adjoining territories will soon make such railway electrification a practical proposition. The electrification, it is thought, would double the speed of trains on the main line and thus help to clear freight congestion at the Indian Ocean ports. A survey will be carried out this year by the East African Railways Administration.

Northern Rhodesian Prosperity

According to a report by the Northern Rhodesian Information Office, the favourable balance of trade for 1953 reached the unprecedented figure of £43,000,000, an increase of over £3,000,000 on the 1952 figure. During 1953, imports rose by £9,000,000 to £51,000,000, and exports, including re-exports, rose by £12,000,000 to £94,000,000.

Exports were naturally dominated by copper, which represented 91 per cent of total exports. With the addition of zinc and lead, all metals formed 96 per cent of total exports. The United Kingdom again provided the bulk of this trade—36·5 per cent of total imports and 60·3 per cent of total exports, while the proportion of exports going to the United States increased from 6·2 per cent to 18·7 per cent over the year. Exports increased by nearly £14,500,000, giving to the Territory a favourable balance of trade with non-sterling countries of £23,750,000, an increase of £14,500,000 over the 1952 figures.

With reference to internal industrial expansion during the year under review it is stated that the existing mines expanded and that prospecting activities by both companies and individuals had increased. Sites for light and heavy industrial undertakings continued to be developed at most main towns. The motor trade in particular expanded and many new garages and workshops were opened. A heavy motor engineering firm started building its premises in the Territory and an existing heavy engineering firm was in the process of starting a nut and bolt factory. Production of tiles was also started.

In addition to the new firms, several old firms were erecting new premises to cope with the expanding trade. The demand for housing kept the building industry working at full pressure and the number of small concerns, both European and African-owned, increased considerably. Steel erection companies were active during the year.

Garage in Durban

A garage capable of parking 2000 cars is being built in Nicol Square, Durban. Provision has been made to land helicopters on its flat roof, which is an acre in extent. The largest parking garage at present is believed to be one in Virginia, in the United States, which can accommodate 1600 cars. Building of the Durban garage started in January. It will have seven storeys with a total area, on all floors, of 9 acres, and will be 600ft long.

Research in High-Energy X-Rays

BY OUR AMERICAN EDITOR

During the past four years the National Bureau of Standards, Washington, D.C., has been conducting an intensive programme of research and development in the field of high-energy X-rays ranging from 2 to 180 MeV. This work is intended to provide information essential to the safe and effective utilisation of the radiations from high-energy particle accelerators in medical treatment, industrial radiography and nuclear physics research. The Bureau employs a 50 MeV betatron and a 180 MeV synchrotron in this work.

THE current programme of research and development which the National Bureau of Standards is conducting in respect of high-energy X-rays has already yielded important data facilitating the safe employment of such radiation in various fields of application. In the course of this programme, radiation from the Bureau's 50 MeV betatron and 180 MeV synchrotron has been used to probe the atomic nucleus, and thus valuable information about its internal structure is being obtained. The development of a crystal spectrometer for selecting radiation of a particular energy has opened the door to the solution of many research problems. Studies have been made of the distribution and absorption of high-energy X-rays in a material simulating the body of a patient, direct visual techniques have been worked out for detecting faults and flaws in metallic structures, recommended practices have been developed for the protection of operating personnel, and standardisation and calibration procedures for high-energy X-rays are being set up. The present work in the field of high-energy radiation is essentially an extension of a programme in low-energy X-rays which the Bureau has been conducting for the past thirty years. This programme has been largely concerned with the development of standards, calibration procedures, and shielding studies, designed particularly for users of X-ray units in the range from 5kV to 1·4 MeV. These machines include 80kV diagnostic X-ray units used by surgeons, radiologists and dentists; 200kV to 1000kV therapeutic sets used by hospitals for cancer treatments, and 1 MeV to 2 MeV units used for industrial radiography of metallic objects. In the course of the low-energy work, the unit for measuring X-rays, the röntgen has been standardised on an international scale, and basic measurement techniques have been developed; the American Armed Services have been assisted in the development and standardisation of field X-ray equipment; other Government agencies have been aided in the design of various instruments, and fundamental calibrations have been performed for industry and the medical profession. The Bureau has also co-operated with the National Committee on Radiation Protection, by providing experimental data and by publishing numerous handbooks containing recommendations for the safe handling of X-rays and radioactive isotopes.

In recent years, the invention and development of high-energy electron accelerators have extended the frontier of available X-rays to the region of thousands of millions of electron volts. High-energy X-rays have several unique properties that make them extremely useful not only in nuclear physics, but in radiation therapy and industrial radiography. To assist the scientific, medical and industrial users of high-energy electron accelerators, the National Bureau of Standards established a betatron section in 1950 as a part of its radiation physics laboratory. The betatron laboratory contains a 50 MeV betatron and a 180 MeV synchrotron, which are being used for the development of measurement techniques and for basic research into the physical characteristics of high-energy X-rays, including their interaction with matter. A considerable portion of the research programme is sponsored by the U.S. Atomic Energy Commission and the U.S. Department of Defence. The accompanying table contains certain data relating to the two particle accelerators at the Bureau.

High-Energy X-Ray Equipment at the N.B.S.

	Betatron	Synchrotron
Radiations	X-rays and electrons	X-rays
Maximum energy ...	50 MeV	180MeV
Weight of magnet ...	11 tons	135 tons
Dimensions of magnet	4ft 3in by 2ft 6in by 3ft 6in	18ft by 8ft by 10ft
Radius of orbit ...	11in	33in
Magnet frequency ...	180 c/s	60 c/s
Injector voltage... ...	50keV	50keV
Maximum field strength	5500 gauss	7200 gauss
Peak yield	1·7 milliwatts per square centimeter at 1 metre	60 milliwatts per square centimetre at 1 metre
R.f. cavity frequency	—	57Mc/s

50 MeV Betatron

The 50 MeV betatron, which is shown in Fig. 1, accelerates electrons by means of magnetic induction. It consists essentially of an a/c electromagnet, the core of which is encircled by the main coil and also by a "doughnut"-shaped vacuum chamber. A beam of 50kV electrons is injected tangentially into the vacuum chamber when the magnetic field has just passed its zero value. As the main coil current increases, the electrons in the vacuum chamber, acting as a secondary winding of a transformer, are accelerated to higher energies. At any instant during their acceleration up to 50 MeV, they may be made to strike an internal target, thus producing a pulse of X-rays with a time width of approximately 10 micro-seconds. The repetition rate of the betatron X-rays is 180 pulses per second. The Bureau has constructed a new energy selector which provides an extremely stable and reproducible energy adjustment for the X-rays. It permits certain experiments to be performed with an energy stability of the order of 20kV out of 40,000,000V. This device consists essentially of a special transformer which produces a pulse when the main magnet current reaches a pre-selected value. The pulse, properly amplified, is then used to deflect the electrons from their orbit against a target.

To extend the usefulness of the betatron, considerable effort has been applied toward the removal of the electrons from the betatron. For this purpose, the Bureau developed a magnetic extractor which makes it possible to study the direct electron interaction with matter at a position remote from the betatron, but proximate to the electron target. The extractor employs a specially constructed coil which is inserted into the vacuum chamber in a position to which the electrons can be deflected. A pulsed current through this coil produces a local magnetic field of 5500 gauss, which is sufficient to cancel the main magnetic guiding field in that region. Furthermore, it produces a field whose

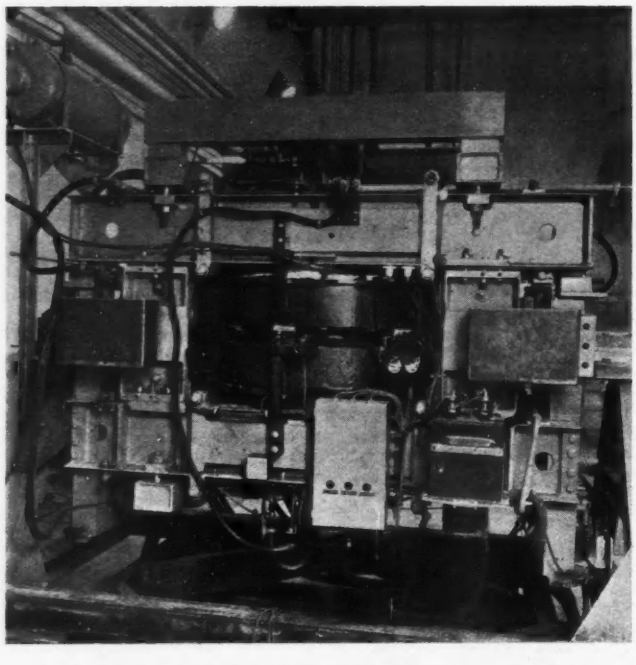


Fig. 1—The 50 MeV betatron at the National Bureau of Standards. The "doughnut"-shaped accelerating tube is situated between the two energising coils

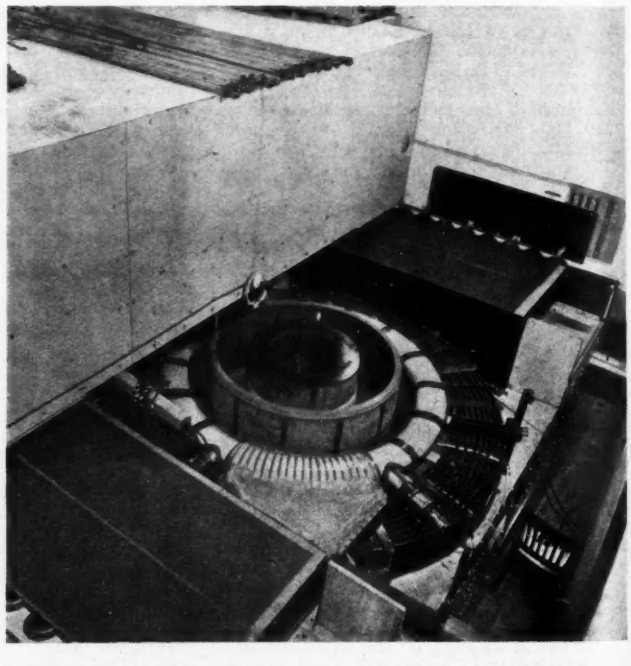


Fig. 2—The 180 MeV synchrotron at the National Bureau of Standards. The upper half of the magnet has been moved to show the "doughnut"-shaped accelerating tube and the electron gun

entire effect increases from approximately zero to its maximum value within a distance of 1mm. This discontinuity is necessary so that the cancelled magnetic field can be felt suddenly by the electrons as they are gradually deflected into the region of this coil. The electrons, upon reaching the region of cancelled magnetic field, travel in an approximately straight path and thus escape from the guiding field of the magnet. The electron beam has been successfully extracted from the betatron at energies up to 24 MeV and with peak currents of the order of 5×10^{-10}A. A large magnet has also been constructed that can focus electrons with energies up to 50 MeV. This magnet, with a focal length of a few metres, will enable the electron beam to be directed against samples as small as a few millimetres in extent and will permit the use of very rare elements or separated isotopes as samples in the study of electron and X-ray effects.

180 MeV Synchrotron

The synchrotron, which is shown in Fig. 2 is very similar to the betatron in appearance. However, to accelerate electrons to the region of hundreds of millions of volts, it is generally more economical to employ an oscillating tangential electric field at one azimuth of the "doughnut"-shaped vacuum tube. This electric field in the N.B.S. synchrotron has a frequency of 57 Mc/s and is synchronised with the frequency of revolution of the electrons in their orbit of 33in radius. Each time the electrons travel through the oscillator section they experience an accelerating impulse. Since the electrons travel most of their path above 2,000,000V, they have an approximately constant velocity, ranging between 98 per cent and 99·99 per cent of the velocity of light. Therefore, there is no need to provide a variable frequency. Acceleration up to 2 MeV is produced by magnetic induction around a flux bar in the centre of the orbit. The magnet, which provides the guiding field and the central acceleration flux, weighs 135 tons and operates at a frequency of 60 c/s. Thus, sixty short bursts of X-rays are produced each second. An extra set of coils on the synchrotron is used to deflect the electrons against the internal X-ray target at any desired energy below 180 MeV. This provides the versatility necessary to determine various effects at different operating energies.

Crystal Spectrometer

The X-rays which emerge from the betatron and the synchrotron comprise an entire spectrum of photon energies ranging from the kilo-electron volt region up to the kinetic energy of the electron which produced the X-rays. The spectrum has a characteristic shape depending upon such things as the target material and the intervening absorbing material. In many experiments individual photons of a particular energy must be selected from this spectrum. Until several years ago, the only suitable instruments in the high energy range were the pair and Compton spectrometers, which are considered to be relatively unwieldy and inefficient. These detectors depend upon the measurement in a magnetic field of the energy of pair or Compton electrons produced by the X-rays in a thin radiator. They have X-ray detection efficiencies of the order of 0·001 per cent.

In order to overcome the handicap of dealing with a multitude of photon energies with inefficient detectors, the Bureau developed a crystal spectrometer having a photon-detection efficiency exceeding 80 per cent and an energy resolution of 11 per cent in the range from 0·5 MeV to 50 MeV. The heart of the spectrometer, which is illustrated in Fig. 3, is a large thallium-activated sodium-iodide crystal. The dissipation of the energy of an individual photon in such a crystal produces a visible light pulse which is detected and measured by photo-multiplier valves, as shown diagrammatically in Fig. 4. The total light output is proportional to the total energy absorbed. The crystal actually consists of two crystals, each 5in in diameter and 4in long. It is sufficiently large to allow practically all the energy of the primary X-ray photon to be absorbed within it. The spectrometer is constructed so that four 2in diameter photo-multiplier valves view the crystal from each end. Their outputs are added to produce one electrical pulse representative of the photon energy. The development of this crystal spectrometer has provided an approach to many experimental research problems which were formerly considered impossible of attack because of the low detection efficiency of available instruments.

Pulse Height Analyser

The wealth of information coming from a crystal spectrometer may be obscured by the distribution of electrical pulse heights. Therefore, it has been found necessary to separate the pulses of different heights into different recording units. However, the standard electronic circuits designed for this purpose are cumbersome and costly. The Bureau, therefore, developed a pulse height analyser which is compact, economical, and particularly well suited for application to any pulsed source such as a betatron or a synchrotron. The N.B.S. pulse height analyser, which is shown diagrammatically in Fig. 5, makes use of a cathode-ray tube. An electrical voltage pulse whose height is to be measured is applied to the vertical deflection plates, thus charging the phosphor of the cathode-ray tube in a line whose length is proportional to the voltage pulse height. During the dead time between betatron pulses, a linear sweep is applied to the same set of vertical deflection plates; simultaneously a set of time gates are started. When the linear sweep passes the end of the original charged line, a pulse is picked up in a wire screen covering the outer face of the cathode-ray tube. This pulse is then accepted in the time gate which is open at that instant. Since the sweep is linear, the time of occurrence of the pick-up pulse is a measure of the height of the initial pulse. Some of the advantages of the system are as follows: (1) A variety of pulse shapes can be accepted for measurement without special pulse shaping networks; (2) more than one pulse occurring in a single cycle can be detected and measured during the off-time of the X-ray source; and (3) the circuit components are straightforward and can be inexpensively constructed.

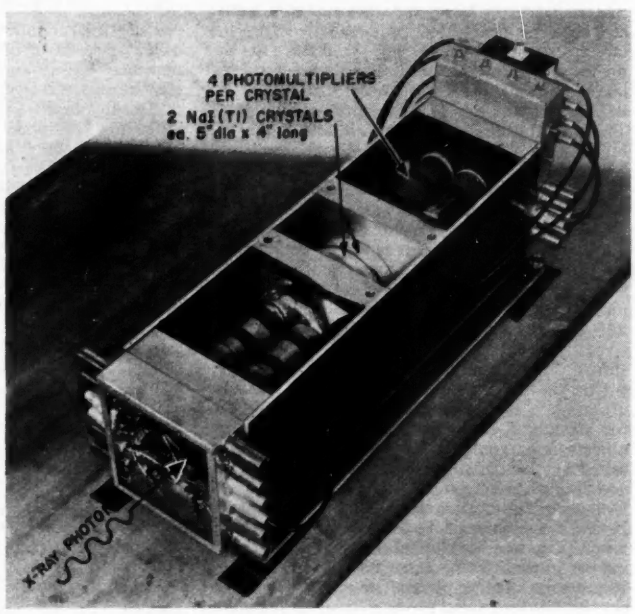


Fig. 3—Total absorption sodium-iodide scintillation spectrometer to measure energies of individual X-ray photons in the range from 0·5 MeV to 50 MeV

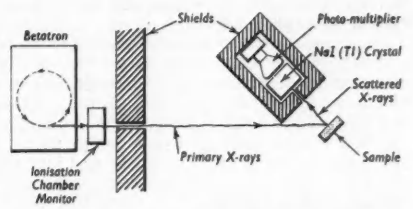


Fig. 4—Diagram of elastic scattering experiment. The primary X-rays are scattered from the sample, and the spectrometer detects only those photons which are scattered from the nucleus with very little loss of energy

Nuclear Physics Research

The high-energy X-rays and electrons generated by the betatron and synchrotron are being used at the N.B.S. to study the interaction of these radiations with the atomic nucleus. The experiments mainly deal with (1) neutron thresholds and yield curves; (2) nuclear absorption, and (3) nuclear scattering of high-energy X-rays. If a nucleus is bombarded with an X-ray or electron of sufficiently high energy, it is possible to break off one or more of the particles of which the nucleus is composed. This effect is being studied using radiations from the betatron. Particular attention is being paid to the threshold for neutron production which has been defined as the smallest energy that must be added to a nucleus in order to eject a neutron. The threshold is determined by observing the neutron yield from a sample as the energies of the electrons or X-rays used to bombard the sample are slowly increased. The neutron yield is measured either by observing the radioactivity that is often induced in the sample by the removal of a neutron or by using a detector to observe the emitted neutron directly. The ability to focus the removed electron beam from the N.B.S. betatron into a small spot makes it possible to use the neutron detector to make measurements of the neutron yield from samples whose size is comparable to the size of the separated isotope samples available from the U.S. Atomic Energy Commission. In a carefully conducted experiment, the threshold energy approximately fixes the energy difference or the mass difference between two neighbouring isotopes.

The absorption and scattering studies are "optical" experiments using photons with energies up to 30 MeV and wave lengths down to 4×10^{-12}cm. These experiments are analogous to some of the early experiments that were carried out in the field of atomic spectroscopy. The experiments in the visible light range gave information that was of considerable value in building up a physical picture of atomic systems. The percentage resolution obtainable with the sodium iodide scintillation spectrometer being used in the N.B.S. nuclear studies is of an order of magnitude less than that obtainable with the spectrometer used for making observations with visible light. This of necessity requires that the nuclear measurements be averaged over relatively broad energy intervals. In spite of this, the nuclear experiments are providing valuable information about the position and strength of the energy levels in various nuclei. The nuclear absorption experiments, which are performed in accordance with the diagram reproduced in Fig. 6, correspond to the studies made with visible light of the dark absorption lines and bands found in a white light spectrum after its passage through vaporised material, such as the isotope lines in the sun's spectrum. In the nuclear experiments the X-ray spectrum produced by the betatron or synchrotron is used as a "white light spectrum." These X-rays are

passed through as much as 9ft of material and the transmitted spectrum shows dips or " bands " in the energy region of strong nuclear absorption by the material under investigation. A study of the position and magnitude of the dips gives information about the energy and strength of the nuclear levels responsible for the stronger nuclear absorption effects.

These nuclear scattering experiments constitute a study of the anomalous dispersion or the fluorescence of various atomic nuclei. These effects are being observed with photons having energies greater than 5 MeV. The probability for the elastic scattering of high energy photons is being measured for various nuclei as a function of photon energy from about 5 MeV to 30 MeV. Optical theory predicts that there will be an elastic scattering associated with an absorption of photons and the absorption and scattering are related by general conservation laws. These relations are being verified for the nuclear absorption and scattering of photons by comparing the results obtained in the scattering experiment with the variable absorption data. In the energy regions where the nuclear absorption is too small to be measured by absorption techniques, the scattering measurements are giving valuable data not otherwise obtainable about the nature of nuclear energy levels. These experiments, together with the nuclear absorption experiments, are providing information which aids in understanding the nature of the energy level systems of nuclei at excitations from 5 MeV to 30 MeV.

Medical Applications

New and improved methods for the treatment of cancer and related diseases are constantly being developed, and several American hospitals have now initiated treatments which use the high-energy X-rays from betatrons and synchrotrons. The N.B.S. betatron section is helping in this work by providing some of the basic measurements required for successful therapy. High-energy X-rays differ from conventional low-energy X-rays in the distribution of the energy absorbed in human tissue. Low-energy X-rays produce a maximum effect at the surface of the skin, with a decreasing effect at greater depths. High-energy X-rays, on the other hand, have only a small effect at the surface, but this effect increases to a maximum at a depth in the tissue dependent upon the X-ray energy. Such an absorption effect is obviously better suited than low-energy X-rays for treatment of deep-seated tumours. The relatively small amount of scattering in the high-energy X-rays also permits greater concentration of the effect of the X-rays on a tumour.

Experiments have been carried out by the Bureau to provide accurate descriptions of these characteristics of high-energy X-rays. In one case a water bath was used to simulate a patient, and a small ionisation chamber and scintillation detector were moved to various locations to map the distribution of ionisation through the water. This experiment was performed at several different operating energies. From these and several subsidiary experiments, basic quantities were determined such as the ratio of energy absorbed in the water to the ionisation produced in an air cavity placed at that position. For the case of betatron X-rays dissipating their energy in water, this ratio is about 90 ergs per gramme for one electrostatic unit of ionisation per cubic centimetre. The importance of the ratio lies in the fact that X-ray dosage is ordinarily measured with small air cavity ionisation chambers, while the quantity of clinical interest is the energy absorbed per gramme of tissue.

Industrial Radiography

The problem of detecting small flaws in large metallic castings or in assembled mechanisms is of great importance to industry. Low-energy X-ray radiography has been used to inspect metallic parts for many years, but it has certain natural limitations for this work. The strong absorption of low-energy X-rays by most materials sharply limits the thickness of material that can be penetrated practically. Also, the large amount of scattering produced in the material being examined and, in most cases, the large size of the X-ray tube focal spot have limited the amount of detail that can be seen. These limitations are much less severe for the high-energy X-rays produced by a betatron. Since most materials are much more transparent to high-energy X-rays, thicker specimens may be examined. The high forward momentum of this radiation greatly reduces diffusion of the X-ray image by scattering and, in conjunction with the small betatron focal spot, produces sharper radiographs allowing the detection of more minute flaws. For these reasons, the use of high-energy X-rays for the radiography of large objects has become increasingly widespread.

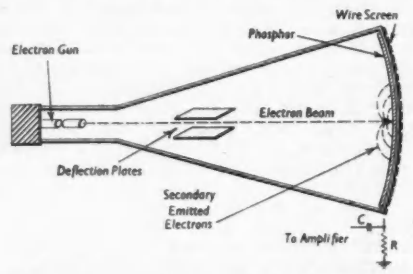


Fig. 5—Diagrammatic view of N.B.S. pulse height analyser used in conjunction with the betatron and the synchrotron

One of the objects of the Bureau's betatron programme is the improvement of techniques for viewing X-ray images transmitted by large objects undergoing inspection. An instrument called a " pattern amplifier " has been assembled and found to have many practical applications. In its most interesting application, it acts as an X-ray image intensifier, continuously detecting, amplifying and displaying low-intensity X-ray images transmitted by large objects. The major component of the pattern amplifier, which is shown diagrammatically in Fig. 7, is the converter. This is a large, cylindrical, thallium-activated sodium iodide crystal, which converts X-ray images into optical images. When bombarded with an X-ray beam which has passed through an object with internal structure, the crystal emits visible light. If the crystal is oriented with its flat faces perpendicular to the X-ray beam, and if it is observed along the beam axis, a visible replica of the X-ray image may be seen. The various crystal converters now being tested have diameters up to 7½in and thicknesses up to 1in.

The visual image may be detected in several ways. For recording purposes, it can be photographed with an ordinary camera. It may be continuously observed by eye, if proper precautions have been taken to protect the observers from radiation. Alternatively, it may be observed with a remotely controlled television camera, which forms part of a closed television chain, transports the image to a safer site, intensifies it, and displays it on a monitor kinescope. With such an arrangement, the pattern amplifier can be used for rapid flaw inspection of large objects, or with the incorporation of a suitable timing mechanism, it can be used for stroboscopic studies of the operation of cyclic mechanisms, such as internal combustion engines. When the converter is viewed by a television camera specially designed for low light intensities, the pattern amplifier is sufficiently sensitive to detect X-ray images with an intensity as low as 2×10^{-5} milliwatts per square centimetre at the crystal. Assuming an available X-ray intensity per 1 milliwatt per square centimetre at a distance of 3m from the 180 MeV synchrotron, the X-ray images produced can still be detected after the X-ray beam has been attenuated by a factor of 50,000. This means that the pattern amplifier can continuously display X-ray images seen through as much as 18in of steel or 7ft 6in of concrete. The resolution does not appear to vary significantly for energies between 20 MeV and 180 MeV.

X-Ray Calorimeter

The interpretation of experimental data obtained with high-energy X-rays generally depends upon an accurate knowledge of the beam intensity. The usual method of measuring beam intensities makes use of an ionisation chamber. This method has been quite satisfactory below 2,000,000V provided normal precautions are taken. However, for higher-energy X-rays the interpretation of an ionisation measurement in terms of beam intensity becomes extremely difficult and contains many uncertainties. For this reason, the Bureau has been engaged in the development of a calorimeter for use as a primary standard in the measurement of high-energy X-ray beam intensities. The N.B.S. calorimeter, consists essentially of a lead cylinder of a size suitable for absorbing most of the X-ray beam. The temperature rise in the lead cylinder due to the absorbed X-rays is compared with the temperature rise produced by a measurable quantity of electrical energy dissipated in the second cylinder. The measurement therefore supplies a direct comparison between X-ray energy and electrical energy. The lead cylinder, which is 4cm in diameter and 7·5cm long, is gold-plated and is suspended by fine dacron threads in a chromium-plated vacuum chamber to reduce heat losses. The entire vacuum chamber is submerged in a constant-temperature water bath. To detect the small temperature changes of the lead cylinder, thermistors are used whose temperature coefficient of resistance is approximately $-3\cdot6$ per cent per deg. Cent. Two such thermistors are used in the lead and are connected in a Wheatstone bridge circuit in order to detect the minute resistance changes associated with the temperature changes in the cylinder. X-radiation power of the order of 0·1 milliwatt for five minutes results in a temperature rise of 2×10^{-4} deg. Cent. and can readily be measured with this calorimeter to an accuracy of a few per cent.

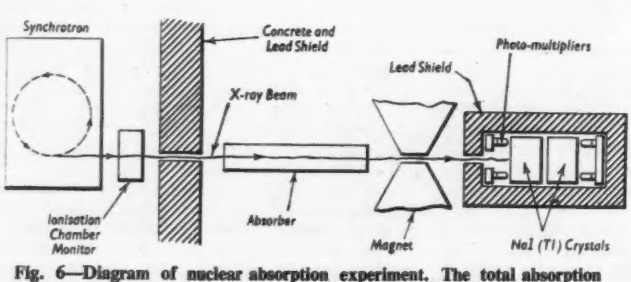


Fig. 6—Diagram of nuclear absorption experiment. The total absorption spectrometer in the lead shield determines the number of X-ray photons at each energy in the transmitted spectrum

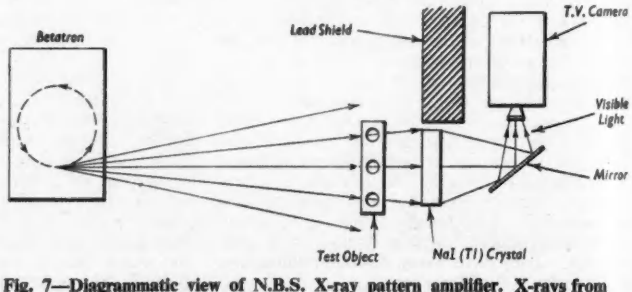


Fig. 7—Diagrammatic view of N.B.S. X-ray pattern amplifier. X-rays from the betatron penetrate the test object to produce a shadow picture which is converted into visible light by the crystal

Industrial and Labour Notes

Engineering and Shipbuilding Wages

On Wednesday evening of last week, it was announced that agreement had been reached between the Engineering and Allied Employers National Federation and the Confederation of Shipbuilding and Engineering Unions on wage increases for adult male workers in the engineering industry. The terms of the agreement, which took effect last Monday, are that skilled men receive an increase of 11s. a week, intermediate grades of semi-skilled men an increase of 9s. 6d., and unskilled men 8s. a week. The basic rates for a forty-four-hour week thus become £7 15s. 10d. for skilled men and £6 12s. 10d. for unskilled men. It is expected that proportionate increases for women and juveniles employed in the industry will now be negotiated. The claim by the unions, which led to the negotiations, sought increases of 15s. a week for skilled men and 11s. a week for unskilled.

It was also agreed at last week's meeting that there should be two weeks' paid holiday a year in addition to the six days of statutory holidays. Hitherto, the statutory holidays have been included as part ot the two weeks' paid holiday. There was also discussion between the Employers' Federation and the union Confederation about a revised wages structure for the engineering industry. An agreed statement which was issued after the meeting said that the parties had had a useful survey of the wage structure, and would continue their examination. They found, however, that any alteration in established practices with regard to the fixing of rates and payment of wages could not be resolved on a short-term basis. Any desirable adjustment, it was agreed, must be gradual if useful improvement was to be secured.

Similar wage increases to men employed in the shipbuilding industry were announced on Tuesday, following discussions between the Shipbuilding Employers' Federation and the union Confederation.

Employment and Unemployment

The Ministry of Labour says that there was an increase of 25,000 in the working population of Great Britain in January, bringing the total at the end of the month to 23,841,000 (16,074,000 men and 7,767,000 women). Of the total, 22,724,000 were in civil employment at the end of January, which denoted a net increase of 10,000 during the month.

An analysis of the civil employment figures shows that in the basic industries in January 3,964,000 people were at work, an increase of 9000 compared with a month earlier. There was an addition of 3000 to the coal mining labour force, which totalled 708,000 at the end of January. There were 378,000 people working in the gas, electricity and water supply industries, 1,691,000 in transport and communications, and 1,027,000 in agriculture. In the manufacturing industries, the number of people employed increased by 35,000 during January to a total of 9,206,000. The biggest addition, of 19,000, was in the "engineering, metal goods and precision instruments" group, the labour force of which at the end of the month totalled 2,731,000, compared with 2,605,000 a year earlier. The number employed in vehicle building in January was 1,219,000, representing an increase of 9000 during the month.

Unemployment figures issued by the Ministry of Labour relate to February 14th, when there were 281,632 people registered as out of work, compared with 297,847 on January 10th. It is stated that the February figure represented 1·3 per cent of the total number of employees. It included 113,000 people who had been employed for more than eight weeks.

Overseas Trade

Provisional figures about the United Kingdom's overseas trade in February put the value of exports at £233,000,000. The Board of Trade says that, taking January and February together, exports average £240,800,000 a month, an increase of 13 per cent compared with the corresponding period of 1954. When the five-month period, October to February, is considered, an increase in the value of exports of 2½ per cent over a year earlier is shown.

Imports in February were valued at £309,500,000, thus making the monthly average for January and February £320,900,000, which was 23 per cent above the average for the corresponding months last year. In the period October, 1954, to February, 1955, the value of imports averaged 12 per cent more than in the comparable period a year earlier. The monthly average value of re-exports in January and February this year was £9,600,000. Thus the excess of imports over total exports was at a rate of £70,000,000 a month in January and February, compared with £59,000,000 a month in the fourth quarter of last year and £40,000,000 a month in January and February, 1954.

Prices of Materials

The Board of Trade says that there was a further rise of 1·9 per cent in the basic materials index in February, mainly as a result of an increase in the price of copper, which, on the average was 13·1 per cent higher than in January. Other price increases in February were tungsten ore (19·4 per cent), tin ingots (2·9 per cent), and zinc (4·3 per cent). The indices for materials used in the mechanical engineering and electrical machinery industries both rose between January and February by 3 and 5·6 per cent respectively. Higher prices for brass ingots and for most other non-ferrous metals and their semi-manufactures caused virtually all the increase in both indices. The indices for building and civil engineering and house building materials rose by 0·7 and 0·4 per cent respectively during February, chiefly on account of increased prices for copper sheets and tubes. The index numbers, which are based on June 30, 1949=100, were as follows at the end of February :—Materials used in the mechanical engineering industries, 163·8 ; materials used in the electrical machinery industry, 183·1 ; building and civil engineering materials, 135·1 ; house building materials, 134·2.

T.U.C. and Automatic Factories

The general council of the Trades Union Congress says that it is keeping a close watch upon the development of automatic operation in industry. A preliminary study has been made through the T.U.C. scientific advisory committee, and unions with experience of automatic or electronic processes are being asked to send in their observations. This preliminary study, it is stated, forecasts that automatic operation will in time develop in many industries and that it will be introduced more and more on jobs of a repetitive character. Already, the T.U.C. points out, automatic processes and electronic controls are commonplace in the steel, chemical and oil industries, and are increasingly used in office work. But, so far as is known, the T.U.C. adds, automatic operation has caused little, if any, redundancy, though some workers have had to change their jobs.

The general council of the T.U.C. considers that much more needs to be known about the probable rate of development of automatic operation in industry. It welcomes particularly the proposal of the Department of Scientific and Industrial Research to undertake research into the matter. By making as many facts known as possible, the T.U.C. says, "a sense of proportion can be maintained about the impact of automatic operation on industrial life and relations." While "automation," as it is called, will undoubtedly raise a number of new questions for trade union negotiators, the T.U.C. general council stresses the need to tackle these problems through the negotiating and consultative machinery of industry. All trade union experience with changing processes in industry, the T.U.C. observes, shows this to be the best way to settle the problems they bring. Finally, the general council of the T.U.C. says it is convinced that trade unions will continue to do their utmost to put their point of view effectively on all questions concerned with industrial efficiency and development.

North East Engineering Bureau

The North East Engineering Bureau, which is established at Newcastle upon Tyne, has just issued its annual report for 1954. In a foreword to it, the board of management says that the report concerns the first complete year of operation of the Bureau since it started to work in conjunction with the Engineering Industries Association in 1953. The report explains that the Bureau's main occupation continues to be the exchange of capacity, and mentions some of the services which it renders to its members. These include the exchange and loan of tools ; locating special tools, plant and material ; the disposal of surplus material and plant ; providing technical advice and literature ; assisting inventors, and liaison with Government departments and trade associations.

The report presents a review of industrial activity during 1954, and also discusses the outlook for the current year. It says that main contracts placed last year with British firms, in the face of keen competition from Japan, Germany and America, revived industry. The subcontract work which has followed has laid a good foundation for believing that the outlook for this year is good. But, the report adds, though the prospects are most encouraging, they bring further problems which industry must solve. Among these problems there is the shortage of labour, especially labour with the necessary technical skill, shortage of material, and restrictions which still hamper some firms in their efforts to expand. Many of these problems, the report comments, can and will be overcome, for they are healthy signs and the result of a period of full employment. There is also a comment in the report about competition from Germany, Japan and the U.S.A. It is apparent, the report states, that in the field of consumer goods, and shipbuilding, there is cause for some concern. Among some of the heavier industries, however, it is emphasised, Britain is more than holding her own, as illustrated by some firms on Teesside which are not only capturing orders from these countries, but are supplying them with plant. Russia, the report adds, does not appear to cause any undue concern in the field of competition ; on the contrary, it is estimated that during the next three years the U.S.S.R. will spend £400,000,000 in this country.

Nickel

The annual report of The International Nickel Company of Canada, Ltd., which has been issued this week, says that the company's deliveries of nickel in 1954 amounted to 282,000,483 lb, and represented about 70 per cent of the total supplies to the free world. Copper deliveries, at 253,275,426 lb, were nearly 19,000,000 lb greater than in 1953. These deliveries, it is stated, included shipments of 24,000,000 lb of nickel and 20,000,000 lb of copper to the United States Government for stockpiling purposes, in accordance with the five-year supply contract entered into in 1953.

Last year, the report records, the company mined 14,456,254 short tons of ore, compared with 13,667,095 tons in the preceding year. At the end of last year, ore reserves stood at 261,619,020 short tons, and the nickel-copper content at the end of the year was 7,874,998 short tons, compared with 7,816,669 short tons at the end of 1953. The underground development in the operating mines reached a total of 375 miles by the end of last year. The report ends by saying it may be confidently expected that during the present year the industrial demand for nickel will continue at a high rate. Before long, it is claimed, the nickel industry will enter a period when ample supplies of nickel will be available to meet all civilian as well as defence requirements.

Personal and Business

Appointments

MR. GORDON A. HICK has been appointed sales director of Whitlock Bros., Ltd., Great Yeldham, Essex.

THE LONDON COUNTY COUNCIL states that Mr. A. J. H. Claydon, A.M.I.C.E., an assistant senior engineer in the chief engineer's department, has been appointed a divisional engineer.

MR. W. J. T. DIMMOCK has been appointed a director and general manager of Hoover (Washing Machines), Ltd., Merthyr Tydfil. He succeeds Mr. A. R. Northover, who has resigned from the board.

WESTLAND AIRCRAFT, Ltd., Yeovil, announces the appointment of Mr. O. L. L. Fitzwilliams as chief engineer. Mr. P. E. Q. Shunker has been appointed chief designer, and Mr. W. D. Murray has been appointed engineering manager.

LONDON TRANSPORT announces the following appointments in the department of the chief mechanical engineer (railways): Mr. G. S. Bingham, M.I.Mech.E., assistant mechanical engineer (works), and Mr. J. G. Bruce, M.I.E.E., assistant mechanical engineer (running).

CABLE AND WIRELESS, Ltd., states that Mr. W. J. Knight, assistant engineer-in-chief, is to become deputy engineer-in-chief in succession to Mr. E. B. Dillow, who is to retire at the end of this month. Mr. R. L. Saunders and Mr. D. Scott have been appointed assistant engineers-in-chief.

MR. F. L. WARING has been appointed managing director of Coalite and Chemical Products, Ltd., Chesterfield, and its subsidiaries, Doncaster Coalite, Ltd., The Derbyshire Coalite Company, Ltd., and The British Diesel Oil and Petrol Company, Ltd. Sir Cyril Entwistle, Q.C., who is a director of the parent company, has been appointed to the boards of the subsidiaries.

B.S.A. TOOLS, Ltd., Mackadown Lane, Kitts Green, Birmingham, announces the following appointments: Mr. A. H. Mason, technical manager; Mr. V. R. Winrow, chief draughtsman; Mr. G. C. J. Legg, deputy general manager of the Cardiff division; Mr. W. W. James, small tools representative of Burton, Griffiths and Co., Ltd., in north-west London and parts of the home counties; Mr. R. W. Nixon, small tools representative of Burton, Griffiths and Co., Ltd., in Northumberland, Durham and the North Riding of Yorkshire.

Business Announcements

THE AEROGRAPH COMPANY, Ltd., states that its sales division is to move, at the beginning of April, to 47, Holborn Viaduct, London, E.C.1.

DOWTY GROUP, Ltd., Cheltenham, states that it has acquired the business of Messrs. Davis, Wynn and Andrews, makers of instruments used in electronics.

MOXEY CONVEYOR AND TRANSPORT COMPANY, Ltd., announces its removal to new premises at 5, Wellington Street, Glasgow (telephone, Glasgow Central 5535).

GEORGE SALTER AND CO., Ltd., states that it will shortly transfer its light spring manufacture from West Bromwich to a new plant in Spring Road, Spon Lane, Smethwick, Staffs.

AERO RESEARCH, Ltd., Duxford, has moved its northern area office to 409, Royal Exchange, Manchester, 2 (telephone, Blackfriars 9445). Mr. S. Hopwood is the area manager.

MESSRS. WILSON AND RODGER, consulting engineers, Western Avenue, Ealing, W.5, have changed the name of the firm to Rodger, Setterington and Partners, consequent upon the retirement of Mr. A. C. Wilson.

THORN ELECTRICAL INDUSTRIES, Ltd., 105–109, Judd Street, London, W.C.1, announces the acquisition of new factories at Pallion Estate, Sunderland; Great Cambridge Road, Enfield, and at Uxbridge, Middlesex.

THE LOEWY ENGINEERING COMPANY, Ltd., has moved to Wallisdown Road, Bournemouth (telephone, Winton 5000; telegrams, "Loewyworks Bournemouth"). Its London office remains at Manfield House, 376, Strand, W.C.2 (telephone, Temple Bar 9881).

DEWRANCE AND CO., Ltd., states that an exclusive licence for the manufacture of its valves has been granted to Ateliers Jaspar, S.A., Liege. The territory covered by the licence includes Belgium, Grand Duchy of Luxembourg, the Belgian Congo and Ruanda-Urundi, and the valves will be made under the trade name "Jaspar-Dewrance."

SUGG SOLAR, Ltd., has been formed as a subsidiary of William Sugg and Co., Ltd., to manufacture in this country the Solar Aircraft Company's "Mars" 40/60 h.p. gas turbine. The Solar Aircraft Company, San Diego, U.S.A., is a shareholder in the new company. Sugg Solar, Ltd., will manufacture this gas turbine at Crawley, Sussex. Mr. R. W. Young is the chairman and Mr. W. T. Mattock, the managing director of the company.

Contracts

HEAD, WRIGHTSON PROCESSES, Ltd., announces that it has received an order from Geothermal Development, Ltd., for a heavy water plant to be erected in the Wairakei district of North Island, New Zealand. In addition to the heavy water plant, the Wairakei development will include a power station, a compound unit and a water pumping station; the source of power is steam which is taken from hot springs, and separation of the heavy water is achieved essentially by distillation in sets of fractionating columns operating in series.

MARCONI'S WIRELESS TELEGRAPH COMPANY, Ltd., has secured an order from the Greek broadcasting authorities for two 148m mast radiators of galvanised lattice steel, complete with r.f. transmission line of the five-wire unbalanced type, aerial matching equipment, an earth system, test apparatus and spares. The masts are to be installed on the island of Corfu, at a coastal site about 3km south-west of the town of Corfu. The aerial matching equipment will be coupled to an existing 50kW transmitter. The installation work is to be carried out by Marconi engineers.

Miscellanea

OBITUARY.—We have learned with regret of the deaths of Mr. Geoffrey T. Perkins and Mr. Lewis R. Langmead, which occurred as the result of a road accident on February 28th. Mr. Perkins was the technical sales manager, and Mr. Langmead technical service manager, of Smiths Aircraft Instruments, Ltd.

BLYTH POWER STATION.—The British Electricity Authority states that it has received the consent of the Minister of Fuel and Power to the establishment of a new power station in Northumberland, to be known as Blyth power station. It will have an installed capacity of 480MW made up of four 120MW turbo-generators served by four boiler units, each having an evaporative capacity of 860,000 lb of steam an hour.

H.M.S. "MURRAY."—The anti-submarine frigate, H.M.S. "Murray," was launched on February 25th at the shipyard of Alexander Stephen and Sons, Ltd., Linthouse. The ship, which has a length extreme of 310ft and a beam of 33ft, is powered by geared steam turbines of advanced design, constructed by the shipbuilder, and will be armed with three Bofors guns and two three-barrelled anti-submarine mortars.

H.M.S. "EXCALIBUR."—Her Majesty's Submarine "Excalibur" was launched at the Barrow yard of Vickers-Armstrongs, Ltd., on February 25th. The submarine is a sister ship to H.M.S. "Explorer" and has an extreme length of 225ft 6in, a length between perpendiculars of 178ft, and a beam of about 16ft. Underwater propulsion will be by the usual battery and main motors, but in addition to the diesel-electric machinery the ship has turbine machinery which derives energy by burning diesel fuel in decomposed hydrogen peroxide.

INDUSTRIAL APPLICATIONS OF NUCLEAR ENERGY.—A series of lectures to coincide with the International Fair at Liége has been arranged by A.I.M. (L'Association des Ingénieurs Electriciens Sortis de L'Institut Montefiore). The lectures will take place on May 3 and 4, 1955, and will be given by speakers from U.S.A., Britain and many continental countries. A fee of Belgian francs 250 will be charged, which will also cover a printed account of the proceedings. Those interested should write to the Secretary of A.I.M., 31, rue St.-Gilles, Liége, Belgium.

COMPANY MAGAZINE OF JOY-SULLIVAN, LTD.—We have received the first issue of a new company magazine entitled *Strata*, published by Joy-Sullivan, Ltd., of Greenock, Scotland. This magazine will be issued quarterly to people engaged in colliery and quarry engineering throughout the world. In an article by Professor G. Hibberd, of Glasgow, on "Mechanisation Through the Ages," he traces the development of coal-cutting machinery from its early days to the present time. News about the company's overseas activities is included, and a record of the development of the "Gloster Getter."

TINPLATE MANUFACTURING PROCESSES.—A booklet has been published by the Tin Research Institute entitled "Some Recent Advances in Tinplate Manufacturing Processes." The booklet is a reprint of a paper presented by Dr. W. E. Hoare to the ninth International Congress on Packaging last September. It reviews the present stage of development of tinplate manufacturing methods. A section on electrolytic tinplate describes all the processes used and the difference in the products, and a chart shows the production method followed in various electrolytic tinplate works throughout the world. Copies of the booklet can be obtained from the Institute's offices, Fraser Road, Perivale, Greenford, Middlesex.

DISCUSSIONS ON CONCRETE ROAD CONSTRUCTION.—The second annual general meeting of the Pavings Development Group (Concrete and Soil-Cement) of the Cement and Concrete Association is to be held at the Institution of Civil Engineers on March 30th. Following the meeting, a number of papers are to be presented for discussion. There will be five papers on concrete highway bridges, describing outstanding bridges constructed in various countries. The application of the lessons learned in airfield construction to large-scale concrete road works forms the subject of another paper, and concrete road construction in the Netherlands, with special reference to the new motorways, will be described.

HEAVY-DUTY WINCH.—A winch designed for heavy-duty work now being made by the Darlington Engineering Company (Gateshead), Ltd., Queensway, Team Valley Trading Estate, Gateshead-on-Tyne, is mounted on a fabricated steel section bed-plate together with the oil engine drive. The drive is taken through a four-speed gearbox and clutch and a worm reduction gear to a pinion and spur wheel. A pull of 30,600 lb is available in first gear, 14,760 lb in second gear, 7700 lb in third gear, and 4550 lb in top gear, the respective rope speeds being 24ft, 50ft, 99ft and 164ft per minute in these gears. The drum is carried in heavy bearings in fabricated steel brackets rigidly bolted to the base frame of the machine and a large diameter friction brake is fitted on the side of the drum assembly. The drum, which can be disengaged from the drive for free spooling, takes 700ft of ¾in rope.

BREADALBANE HYDRO-ELECTRIC SCHEME.—The North of Scotland Hydro-Electric Board has published details of an alteration to the Glen Lochay section of the Breadalbane hydro-electric scheme in Perthshire. The scheme originally provided for the collection of water from the hill streams on the south side of Glen Lochay and on the north side of Glen Dochart by aqueducts and a steel pipeline leading to the power station in Glen Lochay, near Killin. It is now proposed that the water from these burns will be collected at a higher level and led to Loch Lyon, the main storage reservoir of the scheme in Glen Lyon, by a pipeline across Glen Lochay, 5 miles up the glen near Kenknock. This alteration will improve the storage arrangements of the scheme and the water will now pass through the power station at the Lubreoch dam in Glen Lyon on its way to the main power station in Glen Lochay.

PROTECTIVE GOGGLES.—Three new forms of protective industrial goggles are now being made by Safety Products, Ltd., 44, Hatton Garden, London, E.C.1. The first of these goggles, known as the "Contour-Mould" and intended for grinders, is fitted with Nylon plastic eye-cups shaped to the orbital cavity in such a way that smooth, broad cushion edges contact the face all round each eye. The eye-cups are connected by an adjustable nose-bridge consisting of a chain enclosed in a soft Nylon tube. The "Triplex" laminated lenses are mounted in plastic rims which screw on to the eye-cups. A welder's goggle of similar construction has solid instead of perforated side shields to the eye-cups and can be fitted with a selection of lenses, which are protected against pitting by plastic covers. An industrial spectacle also made by the firm has a laminated plastic frame and plastic covered galvanised iron side arms. A number of different forms of lens are available for these spectacles.

OIL PRODUCTION FILMS.—Last week the Shell Petroleum Company, Ltd., presented three films, dealing with the production of oil, with the titles "The Changing Earth," "The Search for Oil" and "The Wildcat." The film "The Changing Earth" shows the action of natural forces and demonstrates the changing of marine organisms, trapped in rock strata, into oil and oil gas. Changes in the structure of the earth's crust are shown by animated diagrams and also the formation of underground structures favourable to the accumulation of oil. A picture of the laborious and costly processes involved in the search for oil is given in the second film, including aerial photography and ground exploration. In the third film "The Wildcat" is shown all the work and techniques involved in the drilling of an oil well from the preparation of the site and the moment of "spudding in" until the well is finally "brought in," while animated diagrams illustrate the underground stages of the drilling. The running times of the films are nine, thirty-one and thirty-three minutes respectively, and copies are available on loan in both 33mm and 16mm gauges from the Petroleum Films Bureau, 29, New Bond Street, London, W.1.

TESTS ON FIRES FOR DOMESTIC HEATING.—A report is published in this month's issue of the *Journal of the Institute of Fuel* on experiments which may help to alleviate the shortage of fuel, and, at the same time, materially improve the existing low standards of room heating by solid fuel, in Great Britain. The paper describes field tests by the Domestic Appliances Laboratories of the British Coal Utilisation Research Association which were undertaken to compare the performance of free-standing open convector fires with restricted throats with ordinary open fires, under conditions of normal domestic operation. The results were obtained from a group of thirty-nine households, all having living-rooms in the same medium-size range. The results indicated that the free-standing convector fires resulted in a fuel saving of approximately 21 per cent, although they were operated for longer periods and were used to maintain higher levels of comfort. The measurements of warmth confirmed these results, and from a series of evening and ten-hour tests it is possible to infer that the free-standing fires were some 60 per cent better than the open fire when judged on the basis of area of warmth per unit burning rate.

British Patent Specifications

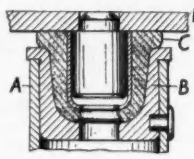
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2 2s. 8d. each.

BEARINGS AND SUPPORTS

724,021. August 4, 1951.—A RESILIENT BUSH, Metalastik, Ltd., Evington Valley Road, Leicester, and Gunnar Ljungstrom, 24, Stamkullevägen, Trollhattan, Sweden.

The invention relates to resilient bushes for bearings and joints, in which a degree of elasticity is desired as in suspension systems for the wheels of motor vehicles. As will be seen from the drawing, the rubber sleeve has a flat lower end with a central hole. The inner surface is curved inwards and has a bonded metal liner fitted within it. A substantial top flange is provided. The bush is shown mounted at the end of a tubular member *A*. A metal seating member *B* for a rubber sleeve *C* is fixed to the tubular member.



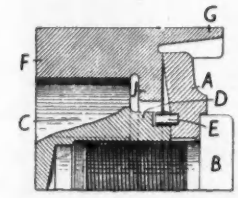
No. 724,021

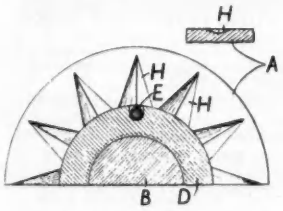
The upper end of the rubber sleeve is pressed against a bracket *D*, which may be secured to a vehicle chassis. Within the metal liner of the resilient bush is shown a stud which has a neck projecting into the bracket.—*February* 16, 1955.

RAILWAY ENGINEERING

723,448. April 22, 1952.—AXLEBOX BEARINGS, Societe Generale Isothermos, 35, rue de La Tour d'Auvergne, Paris.

The aim of the invention is to increase the size of the annular surface with which the collar abuts against the external face of the bearing, without increasing the outer diameters of the collar and the bearing as required by the railway equipment being used. As will be seen from the drawing, a separate collar *A* is fixed in position by a large-diameter central screw *B* in the end of the axle journal *C*. The journal ends in a portion *D* of smaller diameter connected through a perpendicular shoulder with the main portion. One or several pins *E* are provided for holding the collar against rotation. The bearing *F* is formed adjacent to its end *G* with an inner annular projection *J* extending into the space formed by the



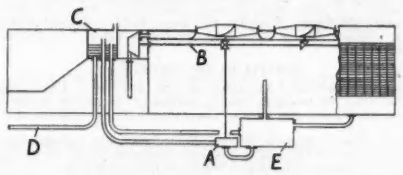


No. 723,448

reduced portion *D* and by the inner machined face of collar. The thrust surface of the bearing is increased to a substantial value with a ratio up to 7 : 1 relative to usual practice. With this separate collar arrangement it is possible to ensure the hydrodynamic lubrication by creating a series of triangular-shaped radial grooves *H* formed at spaced intervals in the inner face of the collar and consisting of faces having an inclination of from 15 deg. to 20 deg.—*February* 9, 1955.

724,026. August 15, 1952.—CONDENSATE FEEDING ARRANGEMENTS FOR CONDENSING LOCOMOTIVES, Henschel and Sohn Gesellschaft mit Beschrankter Haftung, 2, Henschelstrasse, Kassel, Germany.

The invention aims at obviating the drawbacks of feeding condensate to the boiler feed pumps in a condensing locomotive in which a tank is fed with condensate from the condensed water collecting tank by a pump driven by the condenser cooling fan mechanism and the condensate from this tank gravitates to the boiler feed pumps. In the drawing the feed pump is shown at *A*, the drive for the pump being from the shaft *B* of the condenser cooling fan mechanism. The feed pump *A* supplies condensate



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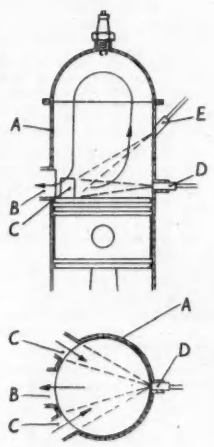
into a tank *C* from which condensate is fed, by gravity, through the pipe *D* to the locomotive boiler feed pumps. The condensate collecting tank for the water supplied via the feed pump *A* is shown at *E*.—*February* 16, 1955.

INTERNAL COMBUSTION ENGINES

723,972. May 22, 1951.—AN IMPROVED TWO-STROKE CYCLE ENGINE, Gutbrod Motorenbau G.m.b.H., Plochingen, Germany.

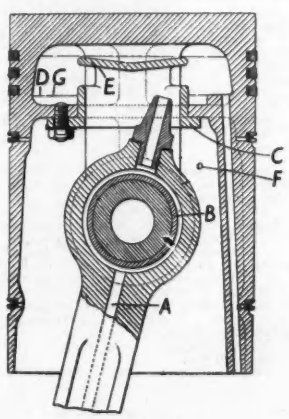
As shown in the drawing, the engine cylinder *A* is provided with a single exhaust port *B* located between two scavenge ports *C*. These ports are uncovered by the piston towards the end of its outstroke, so that a stream of scavenging air flows through the two ports and passes across the cylinder without obstruction, to be deflected by the top of the piston to flow towards the head of the cylinder, where the flow is reversed and, as shown by the arrow, passes out of the exhaust port *B*. A fuel injection nozzle *D* is fitted in the wall of the cylinder opposite the scavenge ports at such a height that its jet is uncovered by the piston when it uncovers the ports. The fuel nozzle directs two jets across the cylinder towards the scavenge ports as the drawing shows. Thus the entering scavenge air receives the impinging fuel jets as it flows upwards. A second fuel nozzle *E* is arranged above the scavenge ports in such a way that a jet of fuel is directed across the cylinder in an inclined path which intersects the upward stream of scavenging air. In the specification modified arrangements of fuel nozzles are also shown.—*February* 16, 1955.



No. 723,972

724,354. May 22, 1953.—PISTONS, Ricardo and Co., Engineers (1927), Ltd., 21, Suffolk Street, Pall Mall, London, S.W.1. (*Inventor: George Allen Holt.*)

The drawing shows that the piston, according to the invention, consists of a flat head with a skirt for



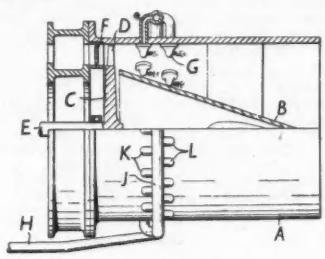
No. 724,354

three piston rings, and two scraper rings. The gudgeon pin bosses are connected to the crown by strengthening ribs. The small end of the connecting-rod has an oil passage *A* and an oil groove *B* surrounding the bearing by which oil is not only delivered to the working surface of the bearing, but also to a nozzle by which a jet of oil is delivered into the upper end of the piston at each revolution of the engine. In the head of the piston is a trough *D* formed by a plate *C* bolted to the piston internal flange and which has a rectangular opening for the swinging end of the oil nozzle. There is also an upper baffle plate *E*. Two outlets *F* from the trough pass down through the thickened bosses in the piston walls. During operation, oil will build up in the space between the piston crown and the trough until stable conditions are reached. Then the quantity of oil in this space is such that during the latter half of each downstroke of the piston, and the first part of the upstroke, the oil thrown into the trough just exceeds the level of line indicated at *G*. A quantity of oil is thereafter ejected through the outlet ducts at each piston stroke. The specification also describes a similar design for a domed top piston. These and other types of trunk piston are described in Specification No. 617,224.—*February* 16, 1955.

GAS TURBINES

723,310. January 11, 1951.—JET PROPULSION UNITS, Sydney Albert Powell, 5, Kingsmead, Monks Risborough, Aylesbury.

The object of the invention is to provide an additional gas for the purpose of augmenting thrust developed by the gases in a gas turbine jet propulsion unit. Referring to the drawing, *A* shows the discharge duct of the jet unit in the interior of which is the



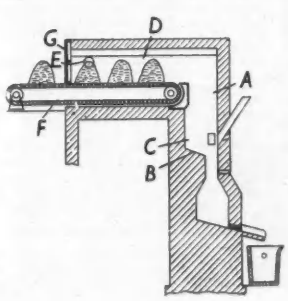
No. 723,310

usual cone *B*. The turbine rotor *C*, with blades *D* is mounted on a shaft *E* which drives the compressor. Upstream of the blades are the nozzle or guide vanes *F*. The jet propulsion unit, according to the invention, is fitted with a series of nozzles *G* for feeding water to the hot gas stream downstream of the rotor *C*, where the temperature conditions are such as not to cause dissociation of the water into its constituent gases, but cause sudden expansion thereby producing increased thrust. The water supply is by means of a main pressure feed pipe *H* connected to an annular branch pipe *J*. The branch pipe supplies water under pressure to two series of radially extending branch pipes *K* and *L* connecting with two series of spaced nozzles *G*. In place of the nozzles *G* the supply of water to the discharge duct may take place through a porous lined chamber or chambers in the wall of the duct.—*February* 9, 1955.

METALLURGY

723,939. July 21, 1952.—MELTING DOWN LIGHT AND BULKY SCRAP METAL, Stahl- und Walzwerke Rasselstein/Andernach A.G. Neuwied, Neuwied, Rhein, Germany.

The invention relates to an improved process of producing charge material for Siemens-Martin and other steel melting furnaces from bulky steel scrap



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pieces in a melting furnace. The furnace, as shown in the drawing, consists of a vertical flue *A* with a melting hearth *B*, above which is a melting space *C*. Connected to the top of the flue at a right angle is a preheating chamber *D*, through which the flue gases pass before being discharged through an opening *E*

into a recuperator, which serves for preheating the combustion air. In the preheating chamber is a conveyor *F*, which serves for conveying the bulky pieces of scrap metal in batches, as indicated. This conveyor belt protrudes out of the preheating chamber so that the pieces of scrap metal can be placed on the belt in front of the furnace and can, after opening the furnace door *G*, be transferred into the preheating chamber *D*. As can be seen from the drawing, the scrap metal parts are moved batch by batch towards the flue *A*, and they are preheated to a very high temperature before being discharged by the intermittent movement of the conveyor belt into the flue and melting space. New scrap metal is not supplied to the hearth until the previous addition is nearly melted away. The time when this occurs can be ascertained by examination through an inspection hole. —*February* 16, 1955.

Launches and Trial Trips

TEANO, short sea trader ; built by Henry Robb, Ltd., for Ellerman's Wilson Line ; length between perpendiculars 260ft, breath moulded 43ft, depth moulded to upper deck 24ft 9in, deadweight 1800 tons on 17ft mean draught, service speed 13 knots ; two holds for general cargo and one hold for refrigerated cargo, derrick complement includes units to lift 3 tons, 5 tons and 10 tons, steam deck machinery ; two 30kW steam-driven generating sets ; one triple-expansion, direct-acting surface condensing, reciprocating engine, cylinders 19½in by 32in by 54in diameter, stroke 36in, built by Swan, Hunter and Wigham Richardson, Ltd., working in conjunction with a Bauer-Wach exhaust turbine constructed by Barclay Curle and Co., Ltd., steam supplied at 210 lb per square inch by two cylindrical multi-tubular boilers. Trial, February 22nd.

BRUIN, cargo ship ; built by Hall, Russell and Co., Ltd.; length between perpendiculars 265ft, breadth moulded 44ft, depth moulded to main deck 19ft 3in, deadweight 2500 tons on 16ft 10in draught ; two holds, four 3-ton, two 5-ton and two 10-ton derricks ; one 12½kW steam-driven generator, one 18kW diesel-driven generator ; Hall, Russell-Fredriksstad No. 6 double-compound, four-cylinder steam motor, steam supplied at 220 lb per square inch and 600 deg. Fah. by two oil-fired cylindrical boilers. Launch, February 24th.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., March 30th.—LONDON SECTION : School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, Discussion Meeting on "The Maintainability of Service Equipment," Speakers A. J. B. Naish, R. B. Brenchley, G. C. Godfrey and G. W. A. Dummer, 6.30 p.m.

ELECTRICAL ASSOCIATION FOR WOMEN

Tues., March 22nd.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, Tenth Caroline Haslett Trust Lecture, Miss M. J. Cumming, 6 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., March 21st.—LEEDS CENTRE : Yorkshire Electricity Board, Ferensway, Hull, Address by H. G. Campbell, 6.15 p.m.
Fri., March 25th.—BATH AND BRISTOL CENTRE : S.W. Electricity Board, Old Bridge Street, Bath, "Shop and Store Lighting," R. L. C. Tate, 7 p.m.
Mon., March 28th.—LEEDS CENTRE : E.L.M.A. Lighting Service Bureau, 24, Aire Street, Leeds, 1, Annual General Meeting, N.C.B. Film, "Buried Treasure," 6.15 p.m.——LEICESTER CENTRE : E. Midlands Electricity Board, Charles Street, Leicester, "The Use of X-Rays in Medicine and Industry," J. E. Hood and G. Whiteley, 6 p.m.
Tues., March 29th.—Lighting Service Bureau, 2, Savoy Hill, London, W.C.2, Discussion on "Home Lighting," 6 p.m.

INCORPORATED PLANT ENGINEERS

To-day, March 18th.—BIRMINGHAM BRANCH : MOBILE PLANT DISCUSSION GROUP : Imperial Hotel, Temple Street, Birmingham, "Soil Stabilisation," E. McKenzie Taylor, 7.30 p.m.
Wed., March 23rd.—BLACKBURN BRANCH : Golden Lion Hotel, Blackburn, Annual General Meeting, 7.30 p.m.
Thurs., March 24th.—SHEFFIELD AND DISTRICT BRANCH : Grand Hotel, Sheffield, Annual General Meeting, 7.30 p.m.
Fri., March 25th.—BIRMINGHAM BRANCH : Imperial Hotel, Birmingham, Annual General Meeting, 7.30 p.m.
Mon., March 28th.—W. AND E. YORKS BRANCH : The University, Leeds, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Tues., March 22nd.—SLOUGH SECTION : High Duty Alloys, Ltd., Slough, "Cylinder Casting," A. Emmerson, 7.30 p.m.
Thurs., March 24th.—NORTHAMPTON AND DISTRICT SECTION : Plough Hotel, Northampton, "Pattern Making for Production Moulding," S. A. Horton, 7.30 p.m.——LINCOLNSHIRE BRANCH : Technical College, Lincoln, Annual General Meeting and Exhibition of Films, 7.15 p.m.
Sat., March 26th.—WALES AND MONMOUTHSHIRE BRANCH : Newport Technical College, Clarence Place, Newport, "Foundry Developments in the Textile Industry," B. Gale, 6 p.m.

INSTITUTE OF FUEL

To-day, March 18th.—E. MIDLAND SECTION : The College, Loughborough, "Application of Gas Turbines to Industry," 7.15 p.m.
Tues., March 22nd.—MIDLAND SECTION : M.E.B. Lecture Hall, Kingsway, Stoke-on-Trent, "Advances in Complete Gasification," F. J. Dent, 7 p.m.
Thurs., March 24th.—Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, Two Papers on "The Development and Use of the Calorimeter Building at the Fuel Research Station, Greenwich," W. F. B. Shaw and J. W. McHugo, 5.30 p.m.
Fri., March 25th.—SCOTTISH SECTION : Royal Technical College, Glasgow, Annual General Meeting, followed by Films, 7 p.m.

INSTITUTE OF MARINE ENGINEERS

Tues., March 22nd.—EDUCATION GROUP : 85, Minories, London, E.C.3, "Annual General Meeting, 5.30 p.m.
Thurs., March 24th.—KINGSTON UPON HULL AND E. MIDLANDS SECTION : Royal Station Hotel, Kingston upon Hull, "The Free-Piston Gas-Generator Turbine as a Power Plant for Ship Propulsion," F. A. I. Muntz and Robert Huber, 7.30 p.m.
Mon., March 28th.—WEST OF ENGLAND SECTION : Smith Brothers Assembly Room, Westgate Buildings, Bath, "Some Factors in the Selection of Machinery for Cargo Liners," L. Baker, 7.30 p.m.

INSTITUTE OF METALS

Mon., March 21st.—SHEFFIELD LOCAL SECTION : University Buildings, St. George's Square, Sheffield, "Protection of Steelworks from Atmospheric Corrosion," F. R. Himsworth, 7.30 p.m.
Tues., March 22nd.—S. WALES LOCAL SECTION : Metallurgy Department, University College, Singleton Park, Swansea, Annual General Meeting, followed by Films, 6.45 p.m.
Thurs., March 24th.—BIRMINGHAM LOCAL SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, "Shielded Arc Welding," E. C. Moore, 6.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Tues., March 22nd.—N.E. ENG. GROUP : Royal County Hotel, Durham City, Papers by Members, 7 p.m.

INSTITUTE OF THE MOTOR INDUSTRY

Tues., March 22nd.—METROPOLITAN REGION : 40, Queen's Gate, London, S.W.7, "The Monte Carlo Rally : Past and Present," J. H. Kemsley and Raymond Gough, 7.30 p.m.

INSTITUTE OF WELDING

Thurs., March 24th.—N. LONDON BRANCH : Polytechnic, Regent Street, London, W.1, "Recent Achievements in Welding Research," H. G. Taylor, 7.30 p.m.
Fri., March 25th.—BIRMINGHAM BRANCH : Midland Institute, Paradise Street, Birmingham, 1, "Principles of Nozzle Design," R. E. Jahn, 7.30 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Tues., March 29th.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Technical Developments in the Lubrication of Tractors," E. S. Bates, 2.15 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Mon. to Wed., March 21st to 23rd.—Church House, Westminster, London, S.W.1, Conference on "The Functions and Education of the Chemical Engineer in Europe."
Wed., March 23rd.—N.W. BRANCH : Technical College, Huddersfield, "The Separation of Organic Mixtures by Solidification from the Melt," J. S. Forsyth and J. Wood, 7 p.m.——MIDLANDS CENTRE, GRADUATES' AND STUDENTS' SECTION : Annual Centre Meeting, followed by "The Role of the Student Section in the Training of the Chemical Engineer," F. Morton, 6.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., March 22nd.—Great George Street, Westminster, London, S.W.1, "A Survey of Modern Concrete Technique," E. E. H. Bate and D. A. Stewart, 5.30 p.m.
Thurs., March 24th.—N.W. ASSOCIATION : Engineers' Club, Albert Square, Manchester, 2, "The Influence of Site Conditions on the Design of Earth Dams," J. B. Holt, 6.30 p.m.
Fri., March 25th.—YORKSHIRE ASSOCIATION : Grand Hotel, Sheffield, "Scale Model Investigation of Hydraulic Engineers' Problems," W. Eastwood, 7 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., March 21st.—RADIO SECTION : Savoy Place, London, W.C.2, Discussion on "Materials for Valves," R. O. Jenkins, 5.30 p.m.
Tues., March 22nd.—EDUCATION DISCUSSION CIRCLE : Savoy Place, London, W.C.2, Discussion on "High-Voltage Equipment in Colleges," T. Siklos, 6 p.m.——LONDON STUDENTS' SECTION : Public Library, Chelmsford, "The Taming of Graduates," J. M. Armstrong, 7 p.m.——SCOTTISH CENTRE : Central Halls, Tollcross, Edinburgh, "Courier to Carrier in Communications," T. B. D. Terroni, 7.30 p.m.
Wed., March 23rd.—SUPPLY SECTION : Savoy Place, London, W.C.2, "Proving the Performance of Circuit Breakers, with particular reference to those of Large Breaking Capacity," J. Christie, H. Leyburn and J. F. Bird ; "A New Testing Station for High-Power Circuit Breakers," J. Christie, H. Leyburn and R. W. Fenn, 5.30 p.m.——S.W. SCOTLAND SUB-CENTRE : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "The Electrification of the Manchester–Sheffield–Wath Lines, Eastern and London Midland Regions, British Railways," J. A. Broughall and K. J. Cook, 7 p.m.
Fri., March 25th.—SCOTTISH CENTRE : Caird Hall, Dundee, "Courier to Carrier in Communications," T. B. D. Terroni, 7.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., March 22nd.—39, Elmbank Crescent, Glasgow, "Supercharging the Marine Diesel Engine," P. Jackson, 7.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, March 18th.—1, Birdcage Walk, Westminster, London, S.W.1, Annual General Meeting, 5.30 p.m.——N.W. BRANCH and N.W., A.D. CENTRE : Lesser Hall, Peter Street, Manchester, "Heavy-Duty Truck Developments in the United States of America," Robert Cass, 6.45 p.m.——E. MIDLANDS GRADUATES' SECTION : Midland Hotel, Derby, "The Professional Engineer in Management," D. H. Bramley, 7.15 p.m.
Mon., March 21st.—SCOTTISH A.D. CENTRE : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Heavy-Duty Truck Developments in the United States of America," Robert Cass, 7.30 p.m.——MIDLAND GRADUATES' SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, "Atomic Energy," J. F. Diamond, 6.30 p.m.
Tues., March 22nd.—AUTOMOBILE DIVISION : 1, Birdcage Walk, Westminster, London, S.W.1, "Discussion, "There is No Future in Great Britain for the Motor Scooter," 6.45 p.m.
Wed., March 23rd.—YORKSHIRE BRANCH : The University, St. George's Square, Sheffield, "Recent Studies of Metallic Friction," F. D. Bowden, 6.30 p.m.——LONDON GRADUATES' SECTION : 1, Birdcage Walk, Westminster, London, S.W.1, "Investigation of Factors Determining the Refrigerating Capacity of a Diffusion-Absorption Refrigerator," C. K. Gulland, 6.30 p.m.—SOUTHERN GRADUATES' SECTION : South Dorset Technical College, Weymouth, "The Refining, Manufacturing and Testing of Lubricating Oils and Greases," R. S. Bassett, followed by Films, 7 p.m.——SOUTHERN BRANCH : Technical College, Brighton, "Back-Pressure Generation," A. R. Morcom, 6.30 p.m.
Thurs., March 24th.—EASTERN BRANCH : Music Room, Assembly House, Norwich, "The Production of a Technical Journal," B. W. Pendred, including a short visit to a Printing Works, 7.30 p.m.——LUTON A.D. CENTRE : Assembly Room, Town Hall, Luton, "Heavy-Duty Truck Developments in the United States of America," Robert Cass, 7.30 p.m.
Fri., March 25th.—GENERAL MEETING, HYDRAULICS GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, "Hydraulic Transport of Solid Material in Pipes," R. C. Worster and D. F. Denny, 5.30 p.m.——SCOTTISH GRADUATES' SECTION : Royal Technical College, Glasgow, Annual General Meeting, "A Locomotive Building Firm in Retrospect," E. F. Clark, 7.30 p.m.

INSTITUTION OF NAVAL ARCHITECTS AND INSTITUTE OF MARINE ENGINEERS

Thurs., March 24th.—SOUTHERN JOINT BRANCH : Technical College, St. Mary Street, Southampton, Annual General Meeting, 7 p.m. ; "Prefabrication in Shipyards," D. M. Kerr, 7.30 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Wed., March 23rd.—INFORMAL MEETING : Conference Room, Fourth Floor, Waterloo Bridge House, London, S.E.1, "The Communications of Staff Co-operation : Lessons from Industry," W. W. Yeats, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, March 18th.—LIVERPOOL GRADUATE SECTION : Stork Hotel, Liverpool, Annual General Meeting, 7.45 p.m.——STOKE-ON-TRENT SECTION : Town Hall, Hanley, Stoke-on-Trent, "Management and Production," H. Bainbridge, 7.45 p.m.——WEST WALES SECTION : Central Library, Alexandra Road, Swansea, "Work Measurement," J. A. Lamond, 7.30 p.m.
Mon., March 21st.—MANCHESTER SECTION : Reynolds Hall, College of Technology, Sackville Street, Manchester, "Manufacture of Commercial Vehicles," A. Hosker, 7.15 p.m.——N.E. SECTION : Neville Hall, Newcastle upon Tyne, Brains Trust Evening, 7 p.m.
Tues., March 22nd.—LONDON GRADUATE SECTION : 10, Chesterfield Street, London, W.1, "Predetermined Time Standards," J. E. Payne, 7.15 p.m.——OXFORD SECTION : Morris Motors, Ltd., Hollow Way, Cowley, Oxford, Annual General Meeting, followed by a Film Show, 7.15 p.m.
Wed., March 23rd.—WESTERN SECTION : Grand Hotel, Broad Street, Bristol, 1, "Motor-Car Manufacture at Vauxhall Motors, Ltd.," R. L. Blades, 7.15 p.m.——WORCESTER SECTION : Cadena Cafe, Worcester, "The Development and Application of Tungsten Carbide Tools," 7.30 p.m.
Thurs., March 24th.—GLOUCESTER AND DISTRICT SECTION : Dowty Equipment, Ltd., Cheltenham, Annual General Meeting, 7.15 p.m.——LINCOLN SECTION : Ruston Club, Unity Square, Lincoln, Annual General Meeting, 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Thurs., March 24th.—11, Upper Belgrave Street, London, S.W.1, "The Development of the Elastic Theory of Continuous Frames," E. H. Bateman, 6 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., March 21st.—MANCHESTER SECTION : Engineers' Club, Albert Square, Manchester, "Ozone Resistance of Butyl Vulcanisates," D. C. Edwards and E. B. Storey, 6.45 p.m.
Mon., March 28th.—MANCHESTER SECTION : Engineers' Club, Albert Square, Manchester, "Application of Rubber to Fibres," T. S. McRoberts and C. D. Hogg, 6.45 p.m.

INSTITUTION OF WATER ENGINEERS

Wed., March 23rd.—Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, "Modifications at Fleam Dyke Pumping Station, Cambridge University and Town Waterworks Company," W. Grant Gibson ; "Features of the Design and Construction of the Hornsey Contact Tank, Metropolitan Water Board," H. K. Davies and A. W. Turner, 2.30 p.m.

IRON AND STEEL INSTITUTE

Wed., March 23rd.—IRON AND STEEL ENGINEERS' GROUP : Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Some Comments on Waste Heat Recovery Practice," W. Gregson, 10.30 a.m. to 12.45 p.m.; "Waste Heat Recovery with Particular Reference to the Generation of Electric Power," W. Ernst, 2 p.m. to 4 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, March 18th.—INFORMAL MEETING : Pepys House, 14, Rochester Row, London, S.W.1, "Some Notes on the Flow of Fluids," R. F. Twist, 7 p.m.
Fri., March 25th.—ORDINARY MEETING : Pepys House, 14, Rochester Row, London, S.W.1, "Amateur Telescope Making," R. D. Gifford, 7 p.m.

LIVERPOOL ENGINEERING SOCIETY

Wed., March 23rd.—24, Dale Street, Liverpool, "High-Pressure Boilers," G. Cook, 6 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

Fri., March 25th.—Engineers' Club, Albert Square, Manchester, Annual General Meeting, "Engineering Problems Associated with Production and Operations at Low Temperature," H. E. Charlton, 6.45 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., March 25th.—Mining Institute, Newcastle upon Tyne, "The Geometrical Size Effect in Notch Brittle Fracture," A. A. Wells, 6.15 p.m.

ROYAL AERONAUTICAL SOCIETY

Thurs., March 24th.—MAIN LECTURE : Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, "Analogue Computing Applied to Aeronautical Problems," K. V. Diprose, 6 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Tues., March 22nd.—12, Great George Street, London, S.W.1, "Value as a Factor in Planning," W. K. Shepherd, 5.30 p.m.

ROYAL SOCIETY OF ARTS

Mon., March 21st.—CANTOR LECTURE : John Adam Street, Adelphi, London, W.C.2, "The Mechanical Properties of Metals : Creep," E. N. da C. Andrade, 6 p.m.

SHEFFIELD SOCIETY OF ENGINEERS AND METALLURGISTS

Mon., March. 21st.—University Building, St. George's Square, Sheffield, "Protection of Steel Works from Atmospheric Corrosion," F. R. Himsworth, 7.30 p.m.

SOCIETE DES INGENIEURS CIVILS DE FRANCE

Mon., March 21st.—Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, "Foundations—Practical Problems in Design and Construction," F. S. Snow, 5.30 p.m.

SOCIETY FOR WATER TREATMENT AND EXAMINATION

To-day, March 18th.—Metropolitan Water Board, Rosebery Avenue, London, E.C.1, "The Standardisation and Selection of Bile Salts and Peptone for Culture Media Used in the Bacteriological Examination of Water," N. P. Burman ; "The Rapid Micro-Estimation of the Major Anions in Fresh Water," F. J. H. Mackereth ; "Fluoridisation of Domestic Water Supplies : Assessment and Maintenance of the Dose to be Applied," J. Longwell, 9.30 a.m.

SOCIETY OF CHEMICAL INDUSTRY

To-day, March 18th.—CORROSION GROUP AND THE LIVERPOOL SECTION : Chemistry Lecture Theatre, The University, Liverpool, "Control of Corrosion in Boilers," P. Hamer, 7 p.m.

WOMEN'S ENGINEERING SOCIETY

Mon., March 21st.—LONDON BRANCH : 35, Grosvenor Place, London, S.W.1, "Oxygen Breathing Apparatus," P. W. Fitt, 6.30 p.m.